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FORESTRY

THE JOURNAL OF THE SOCIETY OF FORESTERS OF GREAT BRITAIN

Edited by R. W. V. PALMER

VOLUME XXV : NUMBER 2

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SOCIETY OF FORESTERS OF GREAT BRITAIN

THIS SOCIETY was formed at Aberdeen in 1925 and adopted its first Constitution at Oxford in 1926. This has been modified several times and the present Constitution became operative in December 1947.

The object of the Society is to advance and spread in Great Britain the knowledge of technical forestry in all its aspects.

The activities include the publication of the journal, the holding of meetings, conferences, and excursions, and the awarding of a medal.

The membership is divided into four classes, the respective qualifications being as outlined below:

FELLOWS: Subjects of the British Crown fulfilling all four of the following requirements: (1) A degree or diploma in forestry, &c. (2) Five years of practical experience in forestry, &c. (3) Having been a Professional Associate for 5 years. (4) Having had a thesis or published article approved by the Council. Annual subscription £1. 11*s.* 6*d.* (Twenty-five guineas for life.)

PROFESSIONAL ASSOCIATES: Subjects of the British Crown fulfilling any one of the following requirements: (1) A degree or diploma in forestry, &c. (2) Having made important contributions to forestry, &c. (3) Considered by the Council to occupy a post normally held by a holder of a university degree in forestry. Annual subscription £1. 1*s.* 0*d.*

PROFESSIONAL MEMBERS: Subjects of the British Crown resident in Great Britain, engaged whole time in forestry but not eligible for above classes. Annual subscription 10*s.* 6*d.*

ORDINARY MEMBERS: Persons or corporate bodies not eligible for any of above classes. Annual subscription £1. 1*s.* 0*d.*

Fuller details of qualifications may be obtained from the Secretary.

Only Fellows are eligible for the higher offices and for most seats on the Council, but one Councillor may be a Professional Associate and one a Professional Member. Office bearers and Councillors are selected by written nomination and postal ballot. Fellows and Professional Associates have full voting rights, but Professional Members have only limited voting rights.

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THE SOCIETY AND ITS JOURNAL

THE IMPORTANCE OF FORESTRY is being realized more and more in Great Britain. The number of foresters is increasing steadily, and a forestry profession is gradually being built up. It is intended that this Society should be representative of the profession. Those who are not engaged in the practice of forestry or the allied sciences are cordially invited to join the Society as Ordinary Members.

THE SOCIETY'S JOURNAL, called *Forestry*, is usually published twice a year, in January and July. It provides a means for the publication of the results of practice and research both in the growing of timber and in its utilization, including such basic sciences as forest physiology and ecology, forest soils, wood structure, and timber physics, and allied sciences such as forest entomology and forest mycology.

CONTRIBUTIONS may be accepted from members and others resident either in Great Britain or abroad. They should be sent to R. W. V. Palmer, Bannerleigh, Leigh Woods, Bristol. No article should be submitted which is being offered to any other journal for prior or simultaneous publication. References to literature should be collected at the end of the paper, and arranged alphabetically according to author's name, and numbered. In the text each reference should be indicated by its number enclosed in brackets. Each article should begin with a summary which should be factual and convey briefly the content of the article and draw attention to all new information and to the main conclusions. It should be concise and should not normally exceed 200 words. It is understood that the author waives any copyright or translation rights in such summaries and that their reproduction in other publications will be permitted, subject to the source being duly acknowledged. Twenty reprints of the article will be sent free to each contributor and a reasonable number may be purchased by the contributor if ordered when the proofs are returned. The Society as a body takes no responsibility for the views expressed by contributors.

Forestry is sent free to members of the Society; others may register as subscribers by application to the Secretary, The Society of Foresters of Great Britain, 7 Albyn Place, Edinburgh, 2.

SOCIETY'S MEDAL. This may be awarded by the Society to any individual who has rendered eminent services to British forestry. Proposals for the award have to be made in the first instance to the Council by a Member of the Council. The regulations for the award will be found in Vol. XX, pp. 80, 81, and in Rule 11.

THE SEMI-JUBILEE OF THE SOCIETY OF FORESTERS OF GREAT BRITAIN

THE Preliminary Meeting, which later led to the foundation of the Society of Foresters of Great Britain, was held in Aberdeen on the 25th September 1925. Mr. (later Sir) John Sutherland was Chairman at that meeting and of the Interim Committee appointed to draft the constitution of the Society. The Society was founded and its constitution adopted at a meeting held in Oxford on the 5th August 1926, during the meeting there of the British Association for the Advancement of Science.

The Council of the Society decided that it would be appropriate to return to Oxford for its Semi-Jubilee Meeting. The Semi-Jubilee Dinner was held in the George Restaurant, Oxford, on the 25th September 1951, and was attended by over 100 members and guests. The toast of 'The Society of Foresters of Great Britain' was proposed by Lord Robinson, who was the first President of the Society, and replied to by Professor Steven, the President of the Society for 1950–1. The toast 'Our Guests' was proposed by Mr. A. H. Gosling, Vice-President of the Society, and reply was made by Major D. C. Bowser of Argaty and the King's Lundies, President of the Royal Scottish Forestry Society, and Mr. David Handley, President of Edinburgh University Forestry Society.

The Semi-Jubilee Annual Meeting of the Society was held in St. John's College, Oxford, on the 26th September 1951, when Professor Steven delivered his Presidential Address.

Lord Robinson's speech at the Semi-Jubilee Dinner and Professor Steven's address at the Annual Meeting are printed on the following pages.

THE SOCIETY OF FORESTERS OF GREAT BRITAIN

By the Rt. Hon. BARON ROBINSON of Kielder Forest and of Adelaide

(Speech made at the Society's Semi-Jubilee Dinner in Oxford, 1951)

I ACCOUNT it a great honour to propose the Toast of the Society of Foresters of Great Britain on this the occasion of the twenty-fifth Anniversary Dinner of its foundation.

It is an appropriate occasion, I feel, to look back to the initiation of the Society and to tell you what I know about that event. The idea was conceived, I think, though I am not quite certain, in Aberdeen and was brought to me at an early stage by John Sutherland, then Assistant Commissioner in Scotland, who asked me to support it. I was a little doubtful at first as to the wisdom of setting up a new Forestry Society when there were already in the country the well-established Royal Scottish and Royal English Arboricultural Societies, to say nothing of the newer Empire Forestry Association. Might it not be better (and cheaper for practising foresters) to strive for a consolidation rather than an increase in numbers? However, it was explained to me that the proposed new Society would be mainly professional in character and devoted more severely to the technical and scientific aspects of forestry in all its branches; further that I, as Technical Commissioner of the Forestry Commission, was bound, almost as a duty, to give it full support. Mr. Sutherland, in a most generous way, further insisted that I should become the first President. So it came about that the Society was formed in 1925 and in August 1926 held its inaugural meeting at Oxford in the classroom of the Forestry School at Oxford where I had so often listened to Schlich's lectures. The audience for the Presidential Address was small, select, and included Lord Clinton, Chairman of the Forestry Commission, and Sir John Stirling Maxwell, who in turn became Chairman a couple of years later.

The Society was extremely fortunate in getting Dr. Steven as Editor, a position which he held for so many years (perhaps he will tell us) and with such distinction.

I have a vivid recollection of a discussion which I had with Dr. Steven about the *Journal*. We were agreed that it must be a worthy production because a Society is known to the outside professional world, as well as to its own members, by its main publication. Our *Journal* therefore must be worthy in all respects, in format and printing as in contents. I am not alone in believing that under Dr. Steven's able guidance this high standard was immediately achieved and has since been maintained. We were very lucky to secure the Oxford University Press as our publishers. Fortunately, in my view, the title *Forestry* had remained unappropriated by any periodical and we were able to adopt it.

I do not propose to tax your patience by attempting to trace the development of the Society from the beginning to the present—that can be better and more appropriately done by someone who has been more closely identified with its

progress. I cannot, however, forbear from saying that it has made sturdy and steady growth, that it has played a most useful part in the development of the profession of Forestry, and forestry itself in Britain.

It was round about the time of the formation of the Society that we were beginning to get a clearer view of the technical problems confronting afforestation. Experimental work was taking a rather more precise form and the *Journal* soon became a convenient medium for the publication of papers which were too technical to appeal to the generality of the readers of the existing forestry journals. Thus *Forestry* began to perform at once a useful function which has gradually increased in importance and must continue so to increase. Not only is the flow of useful knowledge from former large-scale and experimental work assuming considerable dimensions, but the complexity and range of our business expands continuously and with that expansion there arises the need for new investigations. We have come a long way since the beginnings of systematic forestry in Britain and the Editor of *Forestry*, present or prospective, need fear no lack of suitable material.

It is tempting for one at least whose active forestry work has not much further to run to look backwards to the road we have traversed and forward to the future of forestry in this country. In the first two decades of this century there was much talk of an impending timber famine and confident protagonists ventured to predict a fairly definite date for its arrival. American foresters, appalled at the mounting devastation there, were foremost in prophecy. The idea never caught on here, certainly among those who were in high governmental circles or the general public. We all know how difficult it has been for the Commission to secure adequate finance for its work, that is for the promotion of British forestry; how the hard lesson of the First World War was quickly forgotten; how the Second World War reopened everybody's eyes to the importance of timber, or how once again we have to struggle, not so much for finance as for suitable land in quantities adequate to the timber needs of the country. We have been since the end of the war, and to an increasing degree, in the throes of a timber famine or something approaching it and with no very evident relief in immediate prospect. At the best the present position is but a foretaste of what might become a very serious threat to the peace-time or war-time economy of the nation. As I have said, it is still necessary to hammer away on that theme.

In the early days the arguments for increased timber production were received, by and large, with polite scepticism. I will not repeat the counter-arguments which will still be fresh in the minds of my older colleagues. Now, however, we have more goods in the shop window. On the one hand the demands for home-grown timber are so pressing that close control of fellings has had to be instituted. On the other hand, thinnings are beginning to flow freely from the Commission plantations established in the 1920's and early thirties; extensive road-building is necessary and new communities in small villages are being installed in the larger forests. Private owners seem to be awakening to the fact that systematic management, including timely thinning, is a worth-while business.

I have recently made extensive tours in our large Scottish and border forests

and noted with pleasure what successful forestry means in sparsely populated country. There is, so far as I can see, no other means of resettling and developing very large areas of our hill country. Certainly no better scheme has been put forward.

What has been done is only a beginning but it is there for all to see. I am confident that from now onwards the process, if resolutely sponsored, will grow almost of its own momentum.

This leads me to my conclusion and the toast which it is my honour to propose. With a growing industry, such as ours is, it is very necessary that the standards of professional attainment and conduct should be of the highest. The Society of Foresters of Great Britain can and should play the leading part in achieving those high aims. I ask you accordingly to rise and drink with me to its continued prosperity and success.

THE PROGRESS OF TECHNICAL FORESTRY IN BRITAIN 1926–51

By H. M. STEVEN

(Presidential address to the Society of Foresters of Great Britain at the Semi-Jubilee Annual Meeting at Oxford in September 1951)

SUMMARY.

The object of the Society and the position of forestry in Great Britain when the Society was founded 25 years ago are given. The entry into the field of large numbers of university-trained men, whose first task was to extend the forest area of the country, was the essentially new development of the post-1914–18 war period and gains in the technical field have been mainly in the solution of problems arising from large-scale afforestation of state forests. The paper considers briefly the progress made here and goes on to discuss the further problems of natural regeneration, irregular structure of forest crops, pure and mixed woodlands, and three urgent problems of today: the restocking of unprofitable woodland, the introduction of broad-leaved species into the new coniferous plantations, and the problem of tending and its bearing on increment, on timber quality, on markets, and on soil development. We have been slow in applying genetics to forestry but progress should now be rapid. Increased mechanization is necessary in the face of rising labour costs. Finally, if we are to make the best use of our resources both of nature and of man-power, economic considerations must be applied more intensively to the whole range of forestry problems.

INTRODUCTION.

THE object of this Society is to advance and spread in Great Britain the knowledge of technical forestry in all its aspects. While technical forestry has to operate within the limits defined by forest policy, which in turn is influenced by wars—hot or cold—public opinion, politics and economics, I shall assume to a large extent that background of knowledge, and limit myself to a discussion of technical development and problems. Even thus the canvas is large and I can only sketch the outline.

In the year of the foundation of our Society the background was not dissimilar from that today. We were in the aftermath of a world war which had decimated our woodlands and disrupted not only our forestry but our whole economy, and above all, our ideas. The placid and prosperous days of the Victorian and Edwardian eras were gone, but for the first time for over a century the people on these islands were beginning to consider that forestry was an essential national interest. This had led to the establishment of the Forestry Commission, which in 1926 was only an infant and had not long before narrowly escaped murder by an 'axe'. Today it is almost the same picture but in sharper outline and in darker colours. It is true that the Forestry Commission is no longer an infant; indeed, some appear to think that it is a large and menacing giant shutting out the sun.

Before we consider the progress of technical forestry in this country during the past 25 years let us remember that it is rooted in the achievements of past

generations of foresters, both in this and other countries, and of all classes—princes, prelates, noblemen, scientists, and working but observant men. The introduction and trial of all the non-indigenous species we use today, the development of methods of planting, cultivation of planting sites, turf planting, and pioneer planting on peat and other difficult sites and much more had been accomplished, and the results were ready to hand, although the past history of this work was rarely well documented. Moreover, all this was the fruit of private enterprise, and the university-trained forester had up to then played a small part except in the study of pests and diseases of trees.

From the point of view of technical forestry, the essentially new development in the post-1914–18 war period was the recruitment on a relatively large scale of university-trained men to British forestry. This was not the least important result of the State's intervention in setting up the Forestry Commission and the Forest Products Research Laboratory, both children of the 1914–18 war. There is nothing magical about a university education, but its discipline and training cannot but be of value. While British forestry was thus irrigated for the first time, its benefits have not reached in equal measure the whole field of forestry in this country. While there is no sharp line dividing State and private forestry in the technical field, private forestry has had its distinctive problems during the past quarter of a century: the problem of devastated woodlands dates from the first war, the conversion of unproductive coppice and scrub woodland is an old and not a new problem, while economic questions are much more urgent in private than in State forestry. Only a few professionally trained men have devoted their time and energy to these problems of private forestry during most of this period, and what they have accomplished is a measure of what private forestry would have gained from a larger recruitment of university-trained men.

What then has been accomplished in the technical field? The Acland Committee recommendations, on which the Forestry Commission's policy was based until the recent post-war period, had laid on the State department the task of extending the forest area of this country. Assistance to private forestry for the restocking of areas felled in the 1914–18 war was to be mainly financial. Accordingly, the Forestry Commission have been concerned during the inter-war period principally with problems arising from large-scale afforestation.

FOREST NURSERY PRACTICE.

First, there was the production of the necessary planting stock. The commercial nursery trade and some private estates had accumulated the essential technical knowledge and have done something to extend it since. The Forestry Commission built on this foundation and aided by some pure scientists have definitely extended knowledge in this field by research and the experience gained in practice. To begin with, all the traditional techniques were subject to critical study. Later the problem of maintenance of fertility in the widest sense of that complex term emerged as a major problem. Some of the most interesting forest research work of the period has been done in this field and important practical results obtained, such as the choice of heathland for nurseries, the use of composts and fertilizers,

and soil sterilization. The advances in forest nursery practice in Britain compare favourably with that of any other country; only in the United States of America, and in certain subjects, such as mechanization and the chemical control of weed growth, have comparable advances been made.

AFFORESTATION TECHNIQUES.

Much of the land readily available for the extension of our forest area, such as the upland heaths and peat moorlands, was not easy to afforest in the light of the knowledge available in the early twenties. The solution of this problem has been the major task of many of those engaged in State forestry during the past quarter of a century. It has called for the assimilation of knowledge being made available by soil scientists and the study and application of ecological principles. Existing methods of drainage, turf planting, and cultivation have had to be reviewed and developed, and mechanization applied to them. Much work has been done on the use of fertilizers. Finally the important question of choice of species for the varying sites has been studied in great detail. Although all the problems in this field are by no means solved, anyone who has been in close touch with them knows that, while there have been no novel or dramatic advances, there has been substantial progress. This has been clearly demonstrated by the interest which overseas foresters, faced with similar problems, have shown in this work by coming to see what has been accomplished.

FELLED AND DEVASTATED WOODLANDS, ETC.

The problem of restocking felled and devastated broadleaved woodlands has been with us since the 1914–18 war. There is also the cognate problem of conversion of unproductive coppice and coppice-with-standards in England and birch scrub areas in Scotland. In the inter-war period the Forestry Commission carried out experiments in the establishment of broadleaved species, particularly oak, and some work on the conversion of coppice in England and birch areas in Scotland. This, however, is principally a problem facing private forestry and the recent Census of Woodlands shows how large it is. Some private owners and professional foresters, particularly the late Mr. Ray Bourne, have added to our technical knowledge, particularly on the possibilities of making use of natural regeneration in some instances. Much, however, remains to be done in this field, as the President last year indicated, and I shall refer to it again.

TENDING OF FOREST CROPS.

Turning to the tending of forest crops, which will be a major technical problem in the next quarter of a century both in State and private forestry, much useful work has been done both by the Forestry Commission and some private owners and their staffs, particularly in building up knowledge on the thinning régime for the more recently introduced conifers, now used on a large scale. For some of these there is probably greater knowledge in Britain about their thinning requirements than in the countries of their origin or elsewhere. Moreover, knowledge about the techniques of tending both broadleaved and coniferous species is both greater and more widely disseminated in this country than ever before, although there is still much to learn.

TIMBER QUALITIES.

One problem in connexion with the newer exotics such as Sitka spruce, Douglas fir, Japanese larch, Corsican pine, *P. contorta*, and others is the question of their timber quality when grown in this country. During the period under review some investigations have been carried out at the Forest Products Research Laboratory, and service trials designed for uses, such as for pitwood, poles, and railway sleepers. There is no doubt, however, that much more knowledge is necessary both for these exotics and also for our indigenous and earlier introduced species, if silviculture in this country is to be well founded on the quality of its products. In this field there are some disturbing problems.

PROTECTION OF FOREST CROPS.

We now come to the important question of the protection of our woodlands against pests, diseases, and fire. No general concerted action has yet been taken against that scourge of forestry in this country—the rabbit, although the financial saving, directly in reducing fencing costs and indirectly in increasing natural regeneration, would be so great. Here is a task on which forestry, both State and private, and agricultural interests should be able to agree, to the great profit of both in many parts of our country. We have the ever present threat of the innumerable insect pests and fungous diseases of our tree species which calls for continuous survey and study, but, compared with most countries, we have to a considerable degree avoided major calamities from these causes. This is in part due, particularly in the case of insect pests, to the relative absence of exceptional droughts. Many forests on the Continent still show the effect of attacks of pests such as *Ips typographus* following the weakening of trees by the very dry summer of 1947 which was less severe in our maritime climate. One feature of our climate, however, namely the incidence of unseasonable frosts, undoubtedly increases the risk of damage by some fungous diseases such as larch canker. During the period under review the only major disease problem has been the so-called 'Die-back' of European larch, the causes of which are still obscure, but clearly a complex of climatic and biotic causes. Increasing attention has been given to the control of insect pests and fungous diseases by silvicultural means, and our intensive silviculture should enable us to pioneer in this important field. The problems of fire protection have also been given increasing attention, particularly in State forests. Large blocks of young plantations are a high fire risk, and foresters in this country are more fire-minded than ever before.

NATURAL REGENERATION.

Before reviewing some of the more important current problems I should like to refer to some general technical questions of interest and importance. First, foresters in this country have shown increasing interest in the possibilities and place of natural regeneration in the restocking of existing woodlands. This interest is a good thing from every point of view. It is well to remember, however, that we have distinctive obstacles to complete restocking by this means. Most of the species indigenous to this country are not in the optimum part of their range and heavy seed years are infrequent in some instances. We do not yet know very much

about the possibilities of natural regeneration of most of the introduced species, but some, such as Norway spruce, do not regenerate freely. Again, annual maintenance costs, the '*e*' of forest economists, is high in this country, and it would in most instances not be economic to have long regeneration periods covering a number of good seed years. Finally, there is the ubiquitous rabbit and not a few destroyers of seed. While, therefore, I believe that natural regeneration can be used more extensively in this country, when used it should be probably with short regeneration periods and the stocking supplemented by planting. Moreover, over a wide range of conditions, artificial methods will probably remain the principal means of re-establishment of forest crops.

STRUCTURE OF FOREST CROPS.

Another subject which has interested foresters in recent years is the structure of forest crops—whether they should be regular or even-aged as most are in this country, or irregular and uneven-aged. As you know, there has been a trend to the latter in Switzerland and other central European countries, and irregular or selection system structure has had advocates amongst professional foresters in this country, notably the late Mr. Ray Bourne. Personally, I agree that under certain site conditions and where a range of desirable species, varying in tolerance, grows and regenerates, there are many advantages in the irregular structure. It should not be overlooked, however, that while this trend to irregularity has been proceeding in central Europe, in the Northern countries the reverse has been taking place after prolonged study and debate there. And it should be noted that the site conditions and tree species in many of our forests are similar to those in the Northern coniferous forests. The conversion of forests from regular to irregular structure takes a long time and as the restocking of our clear-felled areas must be mainly to relatively even-aged crops in the first instance, there will be plenty of time for professional foresters to study this interesting but complex problem. As with all our problems, it should be thought out in the light of our intrinsic conditions; the solutions must be rooted in them.

PURE OR MIXED WOODLANDS.

Still another interesting but difficult question is pure or mixed crops. We are no doubt all agreed that a certain degree of mixture has important biological if not always economic advantages. Moreover, this is something that Nature does much better than man; the artificial formation of mixed crops is full of practical difficulties. Because of these, most of the plantations formed during the period under review have been pure, although where the site conditions varied, the species have been changed, and individual pure stands may not be large in area. Further, mixtures of sub-climax and climax species have been used on a considerable scale on difficult sites in an effort to telescope succession for economic reasons. In such, the earlier use of, say, alternate rows has been given up to a considerable extent in favour of multiple-row mixtures because of the tending problems that resulted. On the better sites suitable for broadleaved species, mixtures have also been favoured, and in a recent number of the *Quarterly Journal*

Sir Richard Cotterell presented a logical approach to the problem of mixtures from the point of view of later tending. As the restocking of our felled and devastated broadleaved woodlands proceeds, an opportunity will be provided to extend the area of mixed woods in this country, and this should undoubtedly be taken. The introduction of broadleaved species into the large blocks of pure coniferous forest is another problem which I shall touch on later.

MAJOR CURRENT PROBLEMS.

Before I close I wish to say a few words on what appear to me to be the urgent, current, technical problems in this country. First, there are the many technical, economic, and amenity questions arising in the separate but interrelated tasks of restocking the felled and devastated broadleaved woodlands and the conversion of unproductive coppice, coppice-with-standards, and scrub woodlands. If tackled resolutely and skilfully this task is going to greatly extend technical knowledge about species and types of woodland, apart from what it accomplishes directly, just as the struggles to secure natural regeneration on the Continent led to a great advance in silvicultural knowledge. Moreover, this knowledge will overflow and elucidate other problems facing us in this country, as I shall suggest in a minute. Further, this is not only a British problem but will be of great interest not only to other European countries but throughout the world.

Secondly, we have the large new tracts of coniferous plantations. They are forests in name, but they have now to be more closely harmonized with nature and made forests in reality. I think that it was inevitable that this task should be approached in stages in this way. It is in this that the work on devastated woodlands, coppice, scrub, &c., may have value, because professional foresters will thus see what Nature can do unaided and aided. I think that it may prove surprising what Nature herself, if given a chance, can accomplish in making our pure plantations into more natural communities. But the artificial introduction of broadleaved species, not necessarily of trees, will be necessary in many instances either in gaps caused by wind and other natural causes or after thinning. Only thus can our new forests be made to sit more comfortably in their habitats and thus be both more healthy and productive.

The third great problem is the tending of our woodlands, both private and State. We know a good deal about tending, but we need to know much more. For example, we are not yet sufficiently increment-minded in this country, and we must find out how increment is affected by different kinds and intensities of thinning not only in research sample plots but in every wood, and indeed on trees differently sited and lighted. Moreover, there must be more studies on the timber qualities resulting therefrom. Tending problems also link up with the utilization value of different sizes of trees and the economics of the whole subject. When one may be removing two-thirds or more of the total yield in thinnings, prices per size in relation to age at cutting become of obvious importance. Lastly, there is the important effect which tending may have on soil development through its effect on the humus and ground vegetation. We are only at the beginning of such knowledge for our climates and soils.

Then there is the application of genetics to forestry. We have been too slow to take this up intensively, because our type of forestry not only calls for it but gives full scope for the use of its results. There is no reason, however, why progress should not be rapid now, because the science of genetics is very active in this country, as a people we are interested in breeding strains, we are good gardeners, and lastly we have within our shores a particularly rich assemblage of tree species of diverse origins and strains. It would be a mistake to expect quick or dramatic results, but I look forward with confidence to strains with qualities improved in different ways which will extend the resources available to the silviculturist, and perhaps enable him to vary his techniques and increase the productivity and the quality of his products.

The sister industry, agriculture, has made many advances during the past decade in this country, but perhaps the greatest has been in mechanization. There are special difficulties in the mechanization of forest operations, even in the forest nursery. The continual rise in costs of labour, however, will bear with increasing weight on our intensive type of forestry, unless mechanization can be applied successfully to a wider range of operations than we have visualized hitherto. This is one of our most urgent problems, and it may well be that we will have to modify some of our traditional silvicultural practices as part of the solution.

The last problem I have to mention is the more intensive application of economics to the whole range of our forestry problems. The professional forester has constantly to make choices, both of policies and techniques; economic considerations should not be the only criterion, but should be one in helping to make the choices. Just as we should be more increment- and production-minded, we should also be more cost-conscious and link these all together. Only thus can we make the best use of our resources both of nature and of man-power, because in forestry cost means man-power.

In conclusion, I consider that the forestry profession of all grades can look back with some measure of satisfaction over the past 25 years. As in all human endeavour the attainment has been less than it might have been, but some at least of the tasks which the forest policy of the times has laid down have been tackled realistically, and with a measure of success. To some extent the conditions in these islands are distinctive and accordingly the pattern of our forestry is so also. It is the more interesting both to ourselves and to others who come to see it. The tasks which face the profession today are certainly not less difficult than those of 25 years ago, and the problems are not only more varied but even more interesting. Both in numbers and quality the profession is well equipped to go forward with confidence, and I am certain that the President at the Jubilee Meeting in 25 years will be able to say that the prestige of forestry in Britain and of this Society never stood higher.

THE USE OF TIMBER IN MINING[1]

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SUMMARY.

The paper considers briefly the history of the use of timber underground and the general problem of support and goes on to discuss the two main uses for timber in mining, i.e. on roadways and at the coal face, where the two principal methods of working are pillar and stall working and longwall working. Species whose timber is useful for supports are listed and the various kinds of supports given together with the chief factors affecting their behaviour. Replacement of timber by steel is discussed, and in considering the outlook for home-grown timber props emphasis is laid on the need to supply only the best types properly prepared and seasoned.

INTRODUCTION AND HISTORICAL.

FOR most readers the title of this paper may provide vivid—if somewhat inaccurate—mental pictures. Imagination will paint images of subterranean and ill-lit passages, pillared and even lined with roughly cut cylinders of wood; or it will depict a solitary miner lying on his back in a narrow cleft with one slender prop to preserve him from imminent destruction. To most of us, in fact, the use of timber in mines is associated with what government publications call 'propping and shoring purposes underground'. And because such timbering is the mining industry's peculiar problem, this same process must form the main subject of this paper, which will also, it should be noted, deal with the problem as it affects particularly the coal-mines of this country.

It must be mentioned in passing, however, that coal-mining, like any other great industrial operation, calls for vast quantities of joinery and construction timber in addition to mining timber. Pithead erections, preparation plants, workshops, laboratories, offices, miners' houses, all these require timber of every specification and species, whilst the building and repair of railway wagons and the sleepering of hundreds of miles of sidings constantly demand wood at every stage. More than this, mining has its own special technical puzzles in timber utilization

[1] Paper read by Mr. Hollingsworth at the meeting of the British Association for the Advancement of Science at Edinburgh on the 10th August 1951. The reading of the paper was followed on the 13th August by a visit to the Calderhead and Hassockrigg collieries, where members descended to the coal face and were shown all forms of timber supports in actual use. For reasons of economy, the drawings showing the different types of timber supports and certain graphs which accompanied the paper have been omitted. Reference is invited to *The Use of Timber in Mining*, by H. Henshaw, M.I.Min.E., published free by the Timber Development Association Ltd., 21 College Hill, London, E.C. 4, for similar drawings and to the Safety in Mines Research Board Paper No. 72, *Tests on Timber Props*, by Messrs. S. M. Dixon and M. A. Hogan, H.M. Stationery Office, for the graphs.

—the selection of suitable hardwoods for colliery shaft-guides being only one interesting example.

Propping and shoring work underground does, nevertheless, account for most of the huge annual timber consumption of the colleries, a timber consumption higher than that of any other major industry. Indeed, the whole history of mining, and particularly of coal-mining, is bound up with the gradual solution of support problems. For hundreds of years prior to the early eighteenth century, mining was largely confined to the quarrying of outcrops, and even when at last mines were driven and shafts were sunk, few attempts were made to support the strata with timber. The earliest galleries were supported almost entirely by small pillars of coal, and old prints of coal-mining show that timbering, when it existed at all, was of the most rudimentary description. Only the improvement of the steam-engine less than 200 years ago, solving as it did difficulties of pumping, winding, and haulage, brought the question of providing supports to a head. Shafts could now be deeper and underground workings more extensive; some system of strata-control became essential, and the large-scale use of mining timber began.

THE PROBLEM OF SUPPORT.

Before examining methods of support, a word should be said about the reasons for propping and shoring work being necessary. Any detailed description of coal-mining operations is manifestly out of place in a paper of this nature, and the general layout of collieries both above and below ground should be familiar to most readers. It will be sufficient to say that seams of coal lie at various levels beneath the earth's surface, that these seams are not necessarily horizontal but vary in inclination, and that they can be approached either by inclined roadways when shallow or by vertical shafts when deep. The use of shafts for winding coal by various methods to the surface will be familiar to all, but it may not be so well known that, to protect the shaft and the surface buildings of the colliery from subsidence and other disturbances, the coal seams immediately adjacent to the shaft are normally unworked for a considerable area. This area is known as the 'shaft pillar', and only underground roadways are driven through it to the seams beyond.

In the coal seams themselves, at those horizons, where coal has been or is being extracted, there is what seems to the casual visitor a complicated maze of roadways and working-places. Not all the roadways, which are used for ventilation, for the transport of coal to the pit bottom, and for the carriage of tools and materials to the face, are of the same size. There are wide and lofty main roads and narrower 'gate' roads, but all these passages call for daily and hourly observation and attention if they are to remain both safe and efficient channels of communication. The reason for this is obvious. Removal of coal creates a void and upsets the equilibrium of the surrounding strata. Movement is inevitable and some form of artificial support is necessary to avoid ultimate collapse. The amount of support required is governed by the characteristics and inherent strength of the beds forming the perimeter of the excavation and is a continual problem to all those engaged in mining operations.

TIMBERING IN ROADWAYS.

1. *General.*

Until the First World War timber was almost universally used for roadway support and the purchase of a sufficient supply of the correct size and species was a constant problem to colliery executives. Many efforts had previously been made to use alternatives, either in the form of brick arching in conditions where heavy pressures were encountered, or substitution of the timber members by some form of steel joist, but it was not until the 1920s that the latter began to be used on an extensive scale. Since that time progress has been rapid and, today, little more than 30 per cent. of underground roadways in this country are supported by timber.

The chief reason for this decrease has been the introduction of conveyors resulting in the more intensive production of coal. This development has substantially reduced the number of temporary roadways necessary to operate a given length of face whilst, at the same time, concentrating larger outputs along fewer arteries. Consequently, larger roadways supported by a more permanent type of support than timber were necessary and steel has proved the most suitable material to meet this requirement.

Initially the use of steel was limited to the use of ordinary H-section joists in the form of a beam erected on timber uprights and this system is still employed to some extent. But probably the most noteworthy advance was the introduction of the steel arch, which in design and strength has proved the most suitable to meet the exacting conditions of converging strata and maintain a safe roadway without serious deformation. Nevertheless, timber is still used in places where the life of the road is not likely to be extensive, and for lining behind or between the steel arches forming the permanent supports.

2. *Suitable Timber Species.*

The ideal species of timber for use in roadways is European Larch (*Larix decidua* Mill.), which gives a combination of light weight, strength, and durability, found in no other softwood. Its suitability for use in damp conditions and its resistance to fungus are well known but, unfortunately, this species is becoming so scarce that sufficient supplies to satisfy colliery needs are almost impossible to obtain. For ordinary timbering, Scots Pine (*Pinus sylvestris* L.) and Norway Spruce (*Picea abies* Karst.) can be used, provided they are well seasoned, whilst among hardwoods Oak (*Quercus robur* L. and *Q. petraea* Liebe) has been used in some districts because of its great strength. Today the cost of Oak usually forbids its use on roadway timbering. Beech (*Fagus sylvatica* L.) is too heavy, short-grained, and brittle to make a good support timber.

3. *Methods of Support.*

As might be expected, mining conditions have influenced to a large extent the method of support employed, and since timber represents a major and recurring item on any colliery cost sheet, every effort is made (without prejudice to safety) to take advantage of the inherent strength of the strata in deciding the actual system.

Accordingly there are numerous variations of the use of timber as a roadway support. One of the simplest forms is the crossbar or crown tree which is used in 'drawing roads' near to the coal face, particularly where no face conveyor is used. This consists of either a round or half-round section stretching transversely across the roof of the roadway and may be used with or without upright supports. Where no uprights are used the crown tree is needled or recessed into the roadsides and wedged, and this method is therefore limited to conditions where the strata forming the sides does not require support, and is of sufficient strength to withstand the subsequent pressure transmitted through the roof bar. Lids may be used as sole pieces, or placed between the upright and crown tree, to provide for initial crush and extend the life of the timber and, where necessary, lagging pieces may be used either above the crown tree or to support the roadsides, or both.

To counteract side pressure which might easily dislodge an ordinary upright, the top of the prop may be cut to the shape of an inverted V, corresponding notches being cut in the crown tree. In cases of excessive pressure, and particularly where timber is used on main roads, 'herringbone' timbering may be adopted. This consists of using three props running longitudinally along the road and held in position by a further four members in the form of struts, the complete structure accommodating itself to strata movement with increasing resistance. The vertical members may rest on cogs to allow a further margin of compression as the roof strata settles, though, in some cases, these are set on the actual floor. In addition, notching may also be resorted to.

4. *Pit Sleepers.*

Although they are not support-timbers, pit sleepers must be mentioned under the heading of roadways. These are small timber sleepers which carry the flat bottom or bridge rails of the mine car or hutch haulage system. They vary in length and section in accordance with the rail gauge used and preferably are of softwood, as hardwoods used for this purpose are liable to split. As their use is of a more permanent nature than that of face-timbers, pit sleepers are suitable for treatment by preservatives, and tanalizing has in some districts been applied to them with successful results.

SUPPORTS AT THE FACE.

1. *General.*

It may not be generally realized that the distances at which supports are set on the working-faces of collieries are governed by law. The Coal Mines Act and Regulations lay down very definite 'Timbering Rules' which must be exhibited at collieries and which are designed to ensure the safety of miners. The necessity for such regulations will be appreciated when it is realized that each year between 50 and 60 per cent. of the total underground fatalities in British coal-mines are caused by falls of ground.

2. *Methods of Working.*

How supports are set at the working-face depends, of course, on the method which is being used to work the seam. This method will belong to one of two main classifications. Either it will be Pillar and Stall (or, as it is called in Scotland, Stoop and Room) Working or it will be Longwall Working, and a word or two must be said about both these systems.

(*a*) *Pillar and Stall Working.* This is used for thick or moderately thick seams. Its operation may be divided into two parts:

(i) Driving places in the solid coal and dividing the area to be worked into square or rectangular blocks or pillars by narrow places known as 'stalls', 'rooms', or 'drifts'.

(ii) Extracting the pillars and allowing the roof to fall in and fill up the space left. This is the most difficult part of the work, and is sometimes not undertaken when heavy subsidence must be avoided.

At present pillar and stall working is not extensively used in British collieries, but it may be adopted in a modified form to a greater extent where conditions permit, the governing factor normally being the depth of working.

(*b*) *Longwall Working.* Under this method the coal is extracted in one operation by working one or more straight faces, each of 100 yards or longer in length. The haulage and service roads are made as the coal face advances by ripping the strata forming either the roof or floor, to provide the necessary height, and packing the resultant debris on each side of the roadway to provide support in lieu of the coal already extracted. The first operation of extraction is the under-cutting or 'holing' of the face, generally by mechanical coal-cutters. Next shot-holes are drilled in the coal and it is blasted down. Finally, it is loaded by hand or machinery on to mechanical conveyors. These transport it to the 'gate' road for haulage by other conveyors and/or by hutches to the main road, and so on to the bottom of the shaft.

It will be appreciated that this complete extraction of coal inevitably results in a downward movement by the strata over the whole area which is being worked. The mining engineer's problem is to limit and control this subsidence as much as possible, since it is obviously impossible completely to prevent it, by substituting artificial support equivalent to that removed in the form of coal. This technique is known as Roof Control and is accomplished by erecting stone packs at intervals along the face, the corridor between such packs and the actual coal being temporarily supported by props. These props are arranged at regular intervals in a double row, and each set of two opposite props is bridged by a cross-bar or crown tree which is in contact with and helps to support the roof. Within this avenue of props the face conveyor is operated and, as the coal is extracted, fresh props are set nearer to the new face which has been exposed. Finally the cycle of operations is completed by withdrawing the steel or timber supports from the waste area supported by the packs and shifting the conveyor forward to stand within its new avenue of props.

3. *Timber Supports Used.*

(*a*) *Pit-props.* The round pit-prop (already encountered in the timbering of roadways) forms the basis of support-work at the face whether in pillar and stall or in longwall working. Ideally it should be at one and the same time of minimum weight, maximum strength, and long grain, so that it yields gradually to pressure and does not break off short under crushing stresses. Consequently the pit-prop is seldom a hardwood but is almost always cut from pine or fir, which should be well seasoned, with the bark removed to hasten seasoning and prevent rot. The props should be straight, free from coarse knots, slightly tapered, and the ratio of length to diameter for short props should be approximately 12 to 1. For instance, the general rule is that a 4-foot prop should be 4 inches in diameter, but with long lengths a higher ratio of length to diameter is allowed.

Numerous investigations have been carried out on the use of timber as a support, and the following brief summary compiled from reports of the Safety in Mines Research Board and other investigators outlines the chief factors affecting its behaviour.

(i) Timber is such a variable material that consistent figures for strength are seldom obtained even with props of similar size and of the same material. It is not unusual in one batch of props to find the weakest having only half the strength of the average, and only a quarter the strength of the strongest. Table I shows average results obtained from tests carried out on various species of timber. The props in each case had the ends squared to ensure axial loading and were tested to destruction. The results are therefore higher than might be anticipated in practice; in fact, underground conditions are such that axial loading is virtually impossible and in most cases the resistance of supports is decreased by some 30 per cent. It will be seen from the table that an accurate estimation of prop strengths is difficult, and because of other variables any relationship between strength and length or even diameter lacks consistency. It is, however, well known that the strength of a compression member decreases with increase of its slenderness ratio, i.e. on its length (l) divided by the radius of gyration (k). As (k) for a quadrant is 12 per cent. less than that of a circle of equal area, it is apparent that, when used as upright supports, props should be used whole and not quartered or even halved.

(ii) In general, failure occurs either by buckling or breaking near the middle or by crushing near one end. On the average buckling is more common with longer props and with those containing numerous knots. Normally timber, if properly seasoned, gives warning of approaching failure by a loud snapping noise, though this is influenced by the moisture content and the rate of application of the load.

(iii) Contrary to general opinion there is relatively little 'give' in a wood prop, and failure occurs after a comparatively little shortening.

(iv) Seasoning is of the utmost importance in the preparation of pit-props. Apart from the excessive weight of unseasoned props causing difficulty in handling in the confined spaces underground, the strength is appreciably

reduced and the timber is moreover more liable to attacks by fungi. Generally strength decreases with moisture increase up to about 27 per cent., the fibre-saturation point, and the effect of proper seasoning is to increase the crushing strength by over 50 per cent.

(v) The strength of timber is also influenced by its density, which is also a function of its rate of growth.

In practice, props are erected by being driven tight with a hammer. It is bad practice to set them direct between roof and floor and normally a lid or crown tree is used next to the roof. These have the function of extending the support over a greater area of roof and have a 'cushioning' effect as subsidence occurs, thus assisting in better load distribution. Occasionally the props are tapered for the purpose of accommodating roof settlement, the support 'burring' at the end before fracture. This practice naturally decreases the prop strength by intentionally creating a weakness and has never been widely practised in Scotland.

Reference has already been made to the unaxial loading of props in underground use, and that regardless of measures taken some eccentricity is unavoidable due to gradient of the seam, and differential movement between roof and floor. Nevertheless this emphasizes the need for measures to ensure 'normal' loading on initial setting as far as possible, and the importance of physical perfection of the prop; such knots and other weaknesses are exaggerated by eccentric application of the load.

(*b*) *Crown trees.* As explained under 'Longwall Working', crown trees are set over props to distribute the load and increase the effective area of support. They are rectangular in section, half round, or partially squared. In size they vary according to the work to be done, width in inches being identical with length in feet, common crown-tree sizes being 4 ft. × 4 in. × 2 in., 5 ft. × 5 in. × 2½ in., and 6 ft. × 6 in. × 3 in. Some of these supports, known as 'half-round splits', are simply round props split longitudinally through the centre. These are set with the flat side of the split to the roof. Other crown trees, after being split, are roughly squared in section by having a slab sawn off the rounded side. This is called 'backing'. Again, a crown tree may be 'split, backed, and edged' to bring it nearer to a rectangular section. Finally it may be completely 'square sawn'.

(*c*) *Chocks.* Chocks are a form of support generally used in association with packs at the edge of the waste area opposite the working-face. They are short pieces of timber, preferably of hardwood species, square in section but never of any great size. Typical specifications are 2 ft. × 4 in. × 4 in., 2 ft. 6 in. × 5 in. × 5 in., 3 ft. × 6 in. × 6 in., whilst in some coalfields lengths up to 4 feet are used. Chocks are built up in pairs, each pair at right angles to the next, so as to form a rigid structure between floor and roof. They can sustain heavy loads and are normally used next to the waste edge, particularly where it is decided to collapse the roof beds in the waste area, a practice known as caving. The chock pillar must be tightly set, if necessary with the introduction of timber wedges, and it must be well made of sound, seasoned timber. When it has served its purpose, its removal naturally presents difficulties owing to excessive loading. To overcome this removal problem various devices are used, such as incorporating in the

structure a brick which can be knocked out to collapse the chock pillar. The most ingenious method, however, is the insertion of a steel mechanical-release which can be collapsed safely and used repeatedly.

(*d*) *Sprags and Holing-blocks.* Among other timber supports used at the working-face, there are various small props and blocks actually required by regulation where undercutting is practised. Sprags, for instance, are short props set with lids to support the coal above an undercut which has been made by hand. Holing-blocks of hardwood (similar in specification to short chocks but tapered at one end) are set in the undercut after mechanical coal-cutters have removed a thin layer of coal in the first operation of longwall working. These serve not only in preventing falls of coal but in providing additional support to the roof beds and are an essential part of the general roof control technique.

(*e*) *Lids.* Reference has already been made to that small but essential item of support, the pit lid. This, as its name implies, is a short, rectangular piece of timber, either hardwood or softwood, 9 to 12 inches in length and 1 or 2 inches in thickness. A common size is 9 in. × 5 in. × 1 in., and a good lid should be square cut and of sound timber. Its functions are to take the initial stress and so preserve the prop from damage, to ensure tight fitting of the support, and also to be used as a release-device for withdrawal of the prop. Lids can be set between the prop and the roof or between the prop and the floor and they can be tapered slightly to assist in their application.

REPLACEMENT OF TIMBER BY STEEL AT THE FACE.

Under 'Timbering in Roadways' above, reference was made to the advantages of using steel for supports. On the face, steel props and corrugated steel bars are now also used in many cases in preference to timber props. War-time shortages of timber stimulated the introduction of steel for face supports throughout the coalfields, but with improvement in the supplies position there has been a tendency to revert to wood props, particularly in those collieries where variations in height of seam and other factors made steel supports expensive and their application difficult.

Nevertheless, there are definite advantages in the use of steel props and their application usually results in considerable economy. It is obvious in the first place that a homogeneous material such as steel is capable of much more uniform resistance than a natural product like timber. In addition, their strength is much higher (two or three times greater than for timber props of the same length), they can be withdrawn and used over and over again and, even when damaged, can be reconditioned. In design they lend themselves to the provision of special devices to ensure easy release and the area of the ends can be fixed within limits to suit the penetrative resistance of the strata forming the roof and floor. Moreover, their use at the face in many cases eases the supplies transport problem. Their disadvantages are very heavy weight, high cost, and difficulty of application where the seam varies in height over short distances. Over all, however, the economies are considerable, as compared with timber, where losses can be kept at a reasonable figure. This is largely a question of supervision, and where this

is of a high order the support cost may be reduced by more than 50 per cent., representing a saving of over 1*s.* per ton.

Notwithstanding, it is unlikely that steel will ever be used to the complete elimination of timber props. Indeed, timber props well seasoned, well manufactured, and efficiently used, will continue for many years to protect the British miner in his hazardous task of winning coal for the nation.

THE SUPPLY OF MINING TIMBER.

The quantities of mining timber used in British collieries are enormous, reaching a total of almost 800,000 Gothenburg standards of 180 cu.ft. annually, a figure which represents approximately 2,000,000 tons of wood. The considerable forestry operations required to produce this volume of material can readily be appreciated, and even its carriage from source of supply to colliery involves a heavy and daily demand on the nation's road and rail transport facilities.

Where, it may be asked, does all this timber originate, and who prepares it for use by the collieries? Prior to the outbreak of war in 1939, more than 80 per cent. of the mining timber used in British collieries was imported from the countries of northern Europe, Norway, Sweden, Finland, Russia, Poland, and France being the principal producers. The British purchasers were firms of pitwood importers, located at east and west coast ports, adjacent to the coalfields, and the pitwood cargoes arrived at these ports barked, partly seasoned, and in lengths and diameters suitable for rapid conversion to colliery specification. At the ports the timber was selected out into separate lengths and diameters, cross-stacked for final seasoning, and stocked in extensive yards before processing and dispatch into the coalfields. In species, the timber imported was almost entirely the redwood and whitewood of commerce, i.e. Scots Pine and Spruce, and its popularity in comparison with native timber was due to its straightness, its freedom from coarse knots and heavy butts, its square-cut ends, and, above all, its fully seasoned condition.

With the outbreak of war in 1939 imports gradually dwindled and for the second time in the space of a generation the mining industry turned to home-grown sources for its requirements of support timber. What this involved in the wholesale stripping of our forests is only too well known to every country-lover in the land. Home-grown production increased year after year until by 1943 practically all the pitwood being used in British collieries came from native plantations. The production of coal, which might have been brought to a standstill by shortage of pit-props, was never impeded and the work of the home-grown saw-millers, the Forestry Commission, and the Home Timber Production Department, coupled with a rigid system of rationing imposed by Timber Control, was an important contribution to the war effort.

On the return to peace-time conditions the production of home-grown mining timber commenced to decline and importation of foreign timber was resumed. This was inevitable, since a halt had to be called to the clear felling of standing timber before the country was entirely denuded of woodlands. The former pitwood importers emerged from the war period as wharfingers for the Timber Control, who were the sole United Kingdom purchasers of foreign mining timber.

Later the National Coal Board assumed responsibility for all stocks of imported pitwood, delegating the work of storing and processing to the pitwood wharfingers, who thus now continue part of their pre-war function on behalf of a nationalized industry.

Now that the colliery purchases of home-grown mining timber are returning to 20–30 per cent. of the total required, the question may well be asked 'What is being done to encourage pitwood production as the basis of a healthy home-grown timber trade?' Ambitious reafforestation schemes are afoot to make the country self-supporting as far as timber needs are concerned. These schemes, during the many years they will take to reach fruition, will produce a steadily increasing output of 'thinnings', which are admirably suited for pitwood. Already, in fact, the plantings of the years between the wars are yielding 'thinnings' of excellent quality which can be extracted and processed by home timber merchants. The National Coal Board has expressed its willingness to absorb the pitwood produced from this source of supply, and the Scottish Division has actually increased its consumption of native timber by a considerable percentage since the 1st January 1947, the vesting date for the coal industry.

Table II shows the acquisition of various sizes and classes of timber in Scotland during the past 5 years, commencing with the large increase in imports of foreign timber following 1946. The classification of props by sizes is interesting and indicates the considerable use of smaller sizes for use in thinner seams—a position likely to remain without substantial alteration, for many years—thus providing a continued market for 'thinnings'.

There is little doubt that colliery timber supplies can be made the basis of a healthy home industry. But, like any other consumer, the coal industry asks for the best type of support when it purchases home-grown pitwood. Much has been said and written about the high prices paid in recent years for imported timber, yet it is not always realized that the foreign prop is, generally speaking, better prepared and better seasoned than its British counterpart. Admittedly, much native pine and spruce is more open-grown and has fewer annual rings to the inch than imported softwood. It can, however, and, in the hands of many producers it does, provide good, sound pitwood. What it needs, above all else, is patient seasoning, as too often it reaches the miner on the face in a 'green' and heavy, freshly felled condition.

ACKNOWLEDGEMENTS.

The paper is published with the permission of the National Coal Board and of the British Association for the Advancement of Science. The authors would like to express thanks for permission, which has been granted by the Controller of H.M. Stationery Office, to reproduce Table I from the Safety in Mines Research Board Paper No. 72, *Tests on Timber Props*, by Messrs. S. M. Dixon and M. A. Hogan.

TABLE I. *Tests on round props. Average results*

Description	*Number of specimens*	*Nominal length*	*Diameter (in.)*	*Moisture (per cent.)*	*Density of timber (lb./cu.ft.)*	*Crushing strength of timber (lb./sq.in.)*	*Maximum load carried by prop*				*Shortening at maximum load (per cent.)*	*Estimated max. unit stress if tested room dry*
							Unit stress (lb./sq.in.)	*Total (tons)*	*Percentage variation of unit stress in single props*			
									Maximum	*Minimum*		
Home-grown		ft. in.										
Scotch Fir	1	1 6	3·2	..	..	..	4350	15·6	..	..	..	..
	2	2 0	2·49	..	..	..	2915	6·3	..	..	..	..
	3	2 3	2·62	..	..	..	3023	7·3	..	..	..	..
	2	3 0	3·65	..	..	..	1865	8·7	..	..	..	..
	2	4 0	4·46	..	..	..	2345	16·3	..	..	..	..
Larch (Shropshire)	12	5 0	5·76	42·5	41·5	2300	1480	17·3	139	71·0	0·524	2300
	12	5 6	6·23	40·5	43·8	2520	1328	18·4	134	68·6	0·522	2060
Scots Pine (Aberdeen)	12	5 0	5·89	12·8	34·9	4575	2983	36·2	134	78·8	0·37	2930
	12	6 0	6·79	13·9	31·1	4278	2504	43·1	127	84·5	0·45	2575
Scots Pine (Elgin)	12	5 0	5·32	35·7	32·3	4600	2852	28·3	124	79·2	0·23	4480
	12	6 0	6·31	40·7	36·2	4704	2766	38·6	116	71·6	0·225	4280
Imported												
Norway (Pine, Dry)	10	2 0	3·2	..	30·3	5114	4302	15·4	132	77·2	..	..
	2	2 6	3·2	..	30·4	5880	5005	17·9	..	..	..	..
	3	3 0	3·65	..	31·1	..	4090	19·9	..	..	..	..
	1	4 0	3·95	..	28·5	..	4000	21·8	..	..	..	..
	10	4 6	4·84	12·9	27·4	4455	3597	29·3	138	75·9	0·454	3535
	6	6 0	4·94	10·8	32·4	..	4908	42·0	121	84·8	0·380	4400
	10	6 0	6·69	16·2	29·9	4970	3530	55·0	128	82·0	0·416	3990
Norway (Pine, Wet)	5	4 0	3·55	126·8	53·7	..	2104	9·3	155	70·4	..	3300
	5	6 0	4·94	48·5	36·9	..	2548	22·1	114	81·2	..	4000
	10	6 0	6·67	56·0	40·6	2860	2390	37·2	147	69·8	0·383	3750
French (Maritime pine)	10	5 0	4·87	140·0	61·3	2450	1529	12·9	133	75·5	0·200	2400
	10	5 0	5·30	49·9	35·7	2230	1755	17·6	117	85·5	0·280	2750
	10	5 0	5·19	19·9	29·4	3386	2462	22·9	145	59·3	0·280	3225
	10	5 0	5·12	15·1	28·2	4037	2820	25·8	134	71·3	0·336	3060
	10	6 0	5·79	19·2	29·1	3432	2422	29·3	147	61·5	0·310	3100
	10	6 6	7·17	34·4	33·2	2269	1756	32·0	122	68·4	0·340	2750

Table II. *National Coal Board, Scottish Division:*

Statement showing Home-grown and Imported Timber Acquisitions by Scottish Division from 1946 to 1950

All figures in Gothenburg scale standards. The figures include acquisitions by Scottish Oils and Licensed Mines.

Year		2"	2½"	3"	3½"	4"	4½"	5"	5½"	6"	6½"	7"	7½"	8"	8½" and up	Long Mining Timber	Total round	Splits and/or crowns	Sleepers	Baulks	Pillar wood	Chocks, &c.	Sawn props	Total sawn	Total round and sawn	Less Long Mining Timber converted	Nett Total	Percentage home-grown and imported
	Home-grown .	22	2,415	6,185	5,414	7·549	2,758	5,409	66	1,986	5	71	10	4	..	7,840	39,734	26,007	4,230	23	8,154	3,896	4,621	46,931	86,665	7,007	79,658	79·2
1946	Imported .	..	722	3,179	2,866	4,543	2,192	2,221	231	428	8	5	..	..	..	45	16,440	3,900	92	..	371	102	..	4,465	20,905	..	20,905	20·8
	Total . .	22	3,137	9,364	8,280	12,092	4,950	7,630	297	2,414	13	76	10	4	..	7,885	56,174	29,907	4,322	23	8,525	3,998	4,621	51,396	107,570	7,007	100,563	..
	Home-grown .	37	1,877	3,058	2,884	4,437	1,329	3,998	132	1.045	56	41	2	6	1	6,940	25,843	12,441	3,308	1,326	5,132	3,623	..	25,830	51,673	4,277	47,396	37·8
1947	Imported .	85	3,273	8,236	8,077	13,510	7,164	5,080	763	1,907	305	62	1	..	..	3,309	51,772	21,190	1,268	1,675	3,277	159	..	27,569	79,341	1,272	78,069	62·2
	Total . .	122	5,150	11,294	10,961	17,947	8,493	9,078	895	2,952	361	103	3	6	1	10,249	77,615	33,631	4,576	3,001	8,409	3,782	..	53,399	131,014	5,549	125,465	..
	Home-grown .	13	1,861	3,086	2,301	4,370	1,535	3,543	170	1,170	48	113	..	8	3	7,983	26,204	10,523	3,669	900	6,771	4,636	..	26,499	52,703	5,928	46,775	38·7
1948	Imported .	64	3,041	8,619	7,590	14,327	5,373	4,903	778	1,363	337	64	1	6	..	297	46,763	22,406	2,252	1,679	1,882	328	..	28,547	75,310	1,166	74,144	61·3
	Total . .	77	4,902	11,705	9,891	18,697	6,908	8,446	948	2,533	385	177	1	14	3	8,280	72,967	32,929	5,921	2,579	8,653	4,964	..	55,046	128,013	7,094	120,919	..
	Home-grown .	24	2,859	4,834	3,539	6,022	2,407	4,173	219	1,569	49	144	..	17	4	9,770	35,630	12,945	4,643	822	7,685	4,767	..	30,862	66,492	8,859	57,633	47·4
1949	Imported .	13	2.056	8,149	7,259	14,043	3,862	4,096	658	1,148	176	58	4	9	4	15	41,550	21,467	750	43	245	40	..	22,545	64,095	183	63,912	52·6
	Total . .	37	4,915	12,983	10,798	20,065	6,269	8,269	877	2,717	225	202	4	26	8	9,785	77,180	34,412	5,393	865	7,930	4,807	..	53,407	130,587	9,042	121,545	..
	Home-grown .	3	2,563	5,233	4,233	7,234	2,044	4,287	307	1,243	42	139	..	..	5	8,287	35,620	12,348	4,429	571	6,378	5,820	..	29,546	65,166	8,451	56,715	47·9
1950	Imported .	12	1,307	8,140	7,565	12,620	3,276	3,595	648	1,100	27	73	1	1	2	46	38,413	22,825	541	53	8	5	..	23,432	61,845	48	61,797	52·1
	Total . .	15	3,870	13,373	11,798	19,854	5,320	7,882	955	2,343	69	212	1	1	7	8,333	74,033	35,173	4,970	624	6,386	5,825	..	52,978	127,011	8,499	118,512	..

A STUDY OF GROWTH RINGS IN TREES

By C. G. DOBBS

(*University College of North Wales, Bangor*)

Part II.[1] *A Ring Pattern in European Larch*

SUMMARY.

Errors and difficulties in counting the rings on larch butts (*Larix decidua* Mill.) in the Bristol region during a war-time survey led to an unsuccessful attempt to establish a pattern by the method of measuring ring-widths discussed in Part I. During this work it was found possible to recognize the ring-sequences by means of the pattern of light and dark zones in the growth layers. Two sorts of zones of denser wood were distinguished: the annual band of summer wood ending on the autumn break, here called the 'autumn band', and additional zones having their outer margins within the annual increment, found in 41 per cent. of the rings examined, and here referred to as 'lines'. The width of the ring also was found to be of some help although in plantation trees it is subject to great interference from the effects of competition and management. A high degree of certainty in recognition and dating of the rings was found possible with the aid of these characters, especially the 'lines', many of which were found with great regularity in the same locus in the ring-sequence. A frequency diagram based upon 'line-plots' of 105 butts is presented, and four plates of photographs showing features of the pattern from different places. Examples are given and discussed of the differences in the pattern between different districts within about 50 miles of Bristol, between different sites in the same district, and between different trees on the same site. There were indications that 'line' frequency may tend to increase with the age and hardness of the rocks, provided suppression of the rings is not severe. Very young trees have an exaggerated tendency to 'line' formation, and the pattern is best shown in larch from about the sixth to the thirtieth year of growth. A few sections from other parts of Great Britain (Durham, Kent, North Wales) do not show the pattern in typical form although some features of it are present, and it seems likely that several regional patterns may cover the British Isles. If they have any common basis it must be looked for on very broad lines. The Bristol region pattern in Japanese larch (*Larix leptolepis* Gord.) resembles that in European, but the few sections of other conifers examined present a somewhat different picture. The chief value of the pattern is considered to be that it increases ease and accuracy in the identification of the annual ring, and some practical applications are suggested.

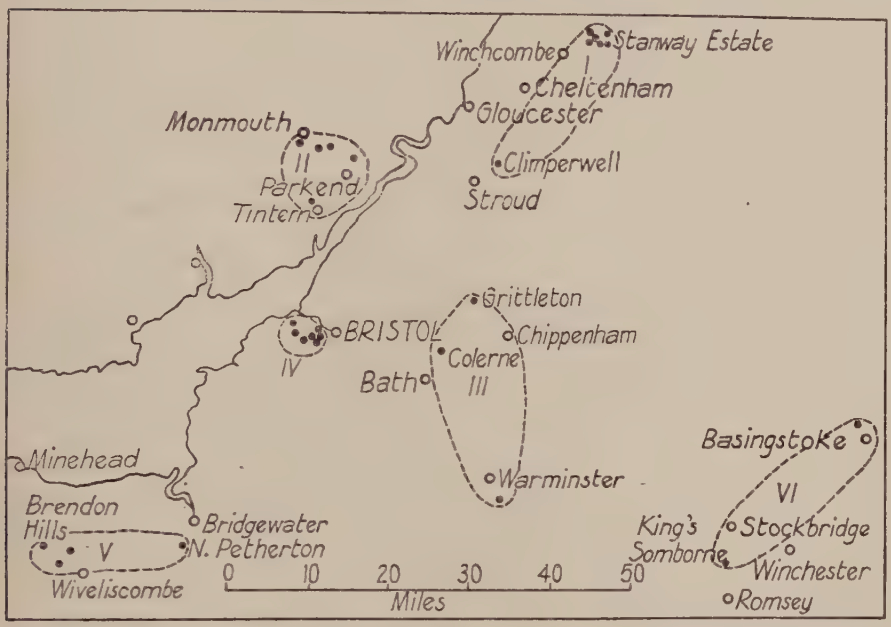
INTRODUCTION: THE UNIVERSITIES' SURVEY, 1940–1.

DURING the summers of 1940 and 1941 a number of University Research Parties, organized from the Imperial Forestry Institute, Oxford, carried out a survey of some of the extensive war fellings then in progress with a view to collecting data which would otherwise have been lost on the growth of various species in relation to soil and site. The writer was a member of one of these parties, centred at Bristol and working within a radius of about 50 miles, roughly from the Quantocks to the south-west, Warminster to the south-east, Chippenham to the east, Winchcomb, Glos., to the north-east, and Monmouth to the north.

This party examined, during the two seasons, some 60 plots, of which 26 were

[1] Part I, *Review and Discussion of Recent Work*, was published in *Forestry*, xxiv, 1951, 22–35.

of European larch, the rest being distributed among other species nearly all conifers. The selection of sites to be visited depended entirely on the felling programme. The location of the 26 plots of European larch studied by the Bristol party is roughly shown in Text-fig. 1, from which it will be seen that they fall into five widely separated districts which have been numbered I to V on the sketch-map. Some material was also obtained from two sites in Hampshire outside the party's area, and these have been included as district VI.



TEXT-FIG. 1. Sketch map of the 'Bristol Area', showing roughly the location of the 28 sites from which European larch sections were obtained, and the six districts into which these sites were arbitrarily distributed.

One of the duties of the writer, who was acting as pathologist to the party, was to examine butts and stumps for signs of butt-rot, and this led to his undertaking the ring count, a task which proved often laborious, and sometimes gave results which were inconsistent with known planting dates or between different trees obviously planted at the same time on the same site.

It was, at first, purely with a view to clearing up these inconsistencies and easing the task of ring-counting that some attempt was made to apply the well-established methods of Douglass and others in the United States to the analysis of these rings. Cross-sections of the butt were made wherever possible, taken back to Bristol, smoothed up with a mechanical plane, and examined in the laboratory with a lens, and where necessary with a travelling microscope. Smooth axe-cuts on butts and stumps also provided some large-enough surfaces to allow the examination of the complete ring-sequence in the field. Most of the work was concentrated on European larch because that species provided the largest amount

of material and also the clearest and most easily read rings. Later it was found that some other species presented no insuperable difficulties and might usefully have been included, but it has been convenient and desirable on grounds of caution to continue to restrict the work to one species.

RING-ANALYSIS: FAILURE OF 'RING-WIDTH' METHODS.

On each section the widths of the annual rings were measured to 0·5 mm. along four radii (i.e. two diameters at right-angles) and the results were averaged and graphed. In general, this method was found to be of no value in the cross-identification of the rings, but revealed the very variable width, both absolute and relative to its neighbours, of the annual increment which may be formed by different trees in the same season. 'Skeleton plots', for instance, of the type used by Glock (4), showing only rings of exceptional narrowness or breadth, were found to be useless.

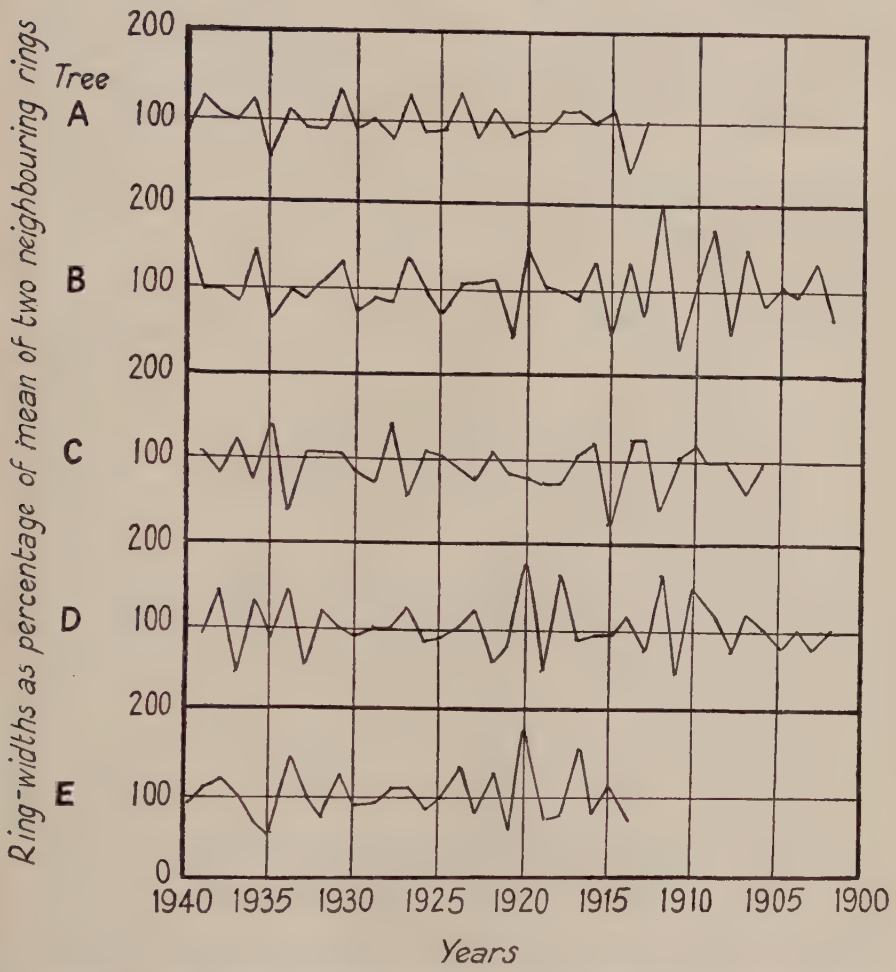
Text-fig. 2 shows the graphs of five larches, later selected from widely scattered sites in south-west England to demonstrate cross-dating by another method. Each ring-width is here expressed as a percentage of the mean of the widths of the two neighbouring rings so as to avoid effects due to different ages of the trees in relation to the grand period of growth. It is quite clear that the amount of correspondence is inadequate for cross-identification, although for selected trees there are periods in which some such correspondence can be traced (e.g. 1925 to 1937 in trees A and B). On the other hand, purely casual similarities in the graphs can be picked out which do not cross-date at all. The years 1906 to 1917 from tree B might be considered to correspond not too badly with the years 1914 to 1925 from tree E. Further 'smoothing' of the graphs merely increases such casual similarities. It may well be that, after careful selection, a few trees may be found to cross-date by ring-widths in a satisfactory manner, but that seems to be of little practical value.

This is in marked contrast to the 'perfect' cross-identification obtained by Douglass (3) from eleven Scots Pine sections sent to him from a plantation at Fleet, near Aldershot, in 1913. These, however, were all from neighbouring trees planted at the same time; and, moreover, there is some indication given in the text that Douglass used other characters than width, e.g. a sharply defined inner edge to the dense wood, although the width is the only character systematically recorded.

Text-fig. 3 shows the graphs of five larches from one plantation (Old Hill, Tyntesfield estate, near Bristol). Here there is an obvious similarity in the last 10 years, doubtless attributable to increasing competition between the trees, released by a thinning about 1934. Apart from this, trees 1, 4, and 5 show a general correspondence not shared by 2 and 3, but on the whole it is less close than might have been expected from trees of the same age and species growing on the same site.

Later experience, however, has shown that width variations, though useless as the sole, or main, criterion in ring-analysis, have some subsidiary value. Certain years, notably the drought years of 1911 and 1921, tend to have somewhat

narrow rings, although this effect is often swamped by the far more extreme and noticeable variations in width produced by local factors, such as competition and thinning, or defoliation. It will be seen, for instance, in Text-fig. 2 that the year

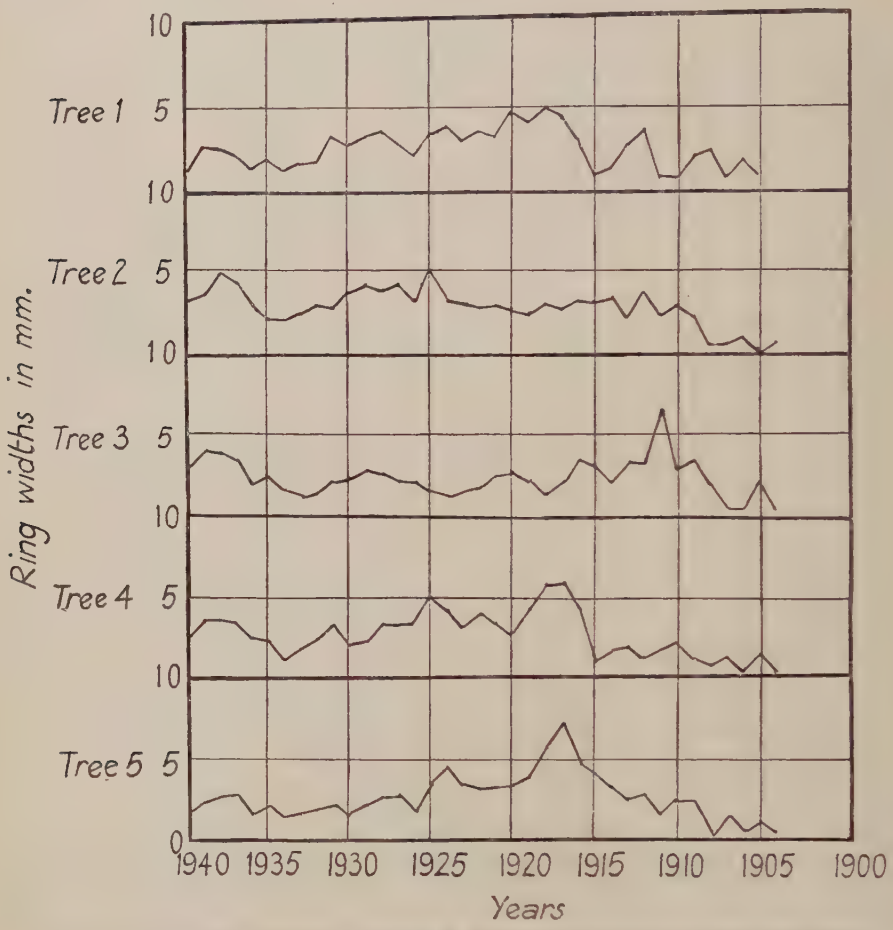


Text-fig. 2. Ring-widths, expressed as percentages of the means of the two neighbouring rings, of five trees selected from widely separated sites, as follows: A, White Hill, near Monmouth; B, Pump Ground, Stanway Estate, near Winchcomb, Glos.; C, Old Hill, near Wraxall, Bristol; D, Huish Cleeve, near Wiveliscombe, Som.; E, Grange Hill Farm, near Basingstoke, Hants.

1921 has in every case a width below the mean of its neighbours, although it would have been marked on a skeleton plot as an exceptionally narrow ring only in two trees (B and E) out of the five. The year 1911 has two narrow rings out of three. Taken alone, these indications are quite inconclusive, but in conjunction with other characters they have been found valuable.

Since the aim of the work was to establish a practicable method of counting and

dating annual rings and ring-sequences in the forest, the classical method of measuring ring-widths was not pursued farther, once it became clear that it was not generally applicable to plantation-grown timber in this country. As pointed



Text-fig. 3. Absolute widths of the rings in five larch trees from Old Hill Plantation, near Wraxall, Bristol.

out in Part I, the successful cross-identification of rings by the 'dendrochronologists' is based upon much longer sequences, and also, usually, upon carefully selected, naturally grown trees, so that the absence of recognizable width-sequences in the material here studied need not imply that no such patterns exist in Great Britain, but merely that, if present, they are largely obscured by the effects of competition and management.

RING RECOGNITION AND NOMENCLATURE.

The correct identification of the annual ring, which is the basic problem in all tree ring work, usually appears to present little difficulty until discrepancies arise

which make it clear that errors have been made. Provided the ring is of reasonable size a close examination of it throughout its circuit will generally reveal its character if its outer boundary does not coincide with the end of the season's growth. But sometimes one cannot be sure (e.g. Pls. VII. 4, and IX. 1, 1930, and Pl. IX. 3, 1918), and unless ring-counting is carried out only after laborious preparation of the section a certain number of 'false' rings are very likely to be counted as annual. And where some rings have been suppressed there can be no certainty about them whatever until the identity of their neighbours can be established.

After the width of the whole ring the relative widths of the spring and summer wood give the most obvious character. Chalk (1) found in Douglas fir (*Pseudotsuga taxifolia* Brit.) that the areas of spring and summer wood varied independently of each other. An attempt was therefore made to measure the widths of the light and dark zones in the rings of larch and to express them as a ratio, but was abandoned owing to practical difficulties. Many rings were so narrow that a travelling microscope was found necessary for their measurement, but under this the margins of the zones frequently lacked the definition necessary for any sort of accurate measurement. This was especially so where more than one light and dark zone occurred in the annual increment.

In such cases it became difficult to apply the terms 'spring' and 'summer' wood with any consistency. Was a darker zone in the first half of the ring to be called 'summer' wood, or a lighter zone in the second half 'spring' wood? The terms 'early' and 'late' wood were scarcely more appropriate. 'Light' and 'dark' could apply only to timbers such as larch with coloured rings. What was actually being observed was the variation in the density of the wood with the size of the lumens of the tracheids. In some rings the size of the lumens could be seen to fall off progressively until the cessation of growth in the autumn; in others there were zones of denser wood followed and bounded on the outside by zones of less dense wood. These denser zones, when clearly defined so that they could be mistaken for annual rings, have been variously referred to as 'false', 'double', 'multiple', or 'additional' rings, but all these terms are open to objection when applied to something which is a normal feature in the formation of conifer wood, at least in the British climate, and which was found to occur in over 40 per cent. of the larch rings examined. It is impossible to draw any boundary between the more and the less conspicuous examples of these denser zones, many of which occupy only a small part of the complete circuit of the stem. The term 'ring' therefore seems inappropriate, and another name has had to be sought to distinguish these zones from the band of dense wood which normally ends the season's growth.

Finally the term 'line' has been adopted, for its convenience and brevity, to designate any zone of denser wood not bounded on the outside by the seasonal cessation of growth. Any such zone which is so bounded is referred to as an 'autumn band' (often abbreviated to 'band'). A thin, prominent, centrally placed additional ring has long been referred to in the literature as a 'mid-line', but in the use of the word here proposed thinness is not necessarily implied. 'Lines', as here defined, may be thin or thick, definite or indefinite in outline.

It was the difficulty of deciding whether or not certain prominent 'lines' were to be regarded as 'autumn bands' for purposes of width measurement which first drew attention to their tendency to occur regularly at certain loci in the ring-sequences. In particular, the realization that a strong 'mid-line' (marked with an arrow in the plates) occurred almost invariably in the 1918 ring provided the solution of many discrepancies in the ring-counts. Not that this 'line' could be recognized by itself, but in conjunction with a later, and rather vaguer, 'line' or pair of 'lines' in the following year, a broad 'band' without 'lines' in 1920, and a narrower ring with thin 'band' and often a thin late 'line' in 1921, it began to make a recognizable sequence.

With improved smoothing of the sections, including glass-papering, more details became visible, and as the work continued and more material was examined, this initial sequence extended itself in the mind into a definite pattern, based upon a subconscious appraisal of the recognizable features of the individual rings in their succession from 1908 to 1930, with some estimate of the range of their variability. Beyond these limits, before 1908 and after 1930, the youth of most of the trees being felled, and the frequent crowding of the outer rings, made the picture somewhat less definite and reliable; but provided some part of it was sufficiently well represented to be recognized, the identification and dating of the rings became for the first time reasonably certain.

THE RING PATTERN.

The presentation of this pattern on the printed page is a matter of some difficulty, involving much simplification and selection. The photographs in the four plates have been selected to give some impression of its range.

An arbitrary notation was developed for the purpose of abbreviating the records of the main characters of the rings, which were eventually reduced to the following, for each annual ring:

Width: broad, narrow, very narrow, variable, partial (followed by a figure giving the percentage of the circuit present), missing.

'*Autumn band*': broad, narrow; 'hard' or 'soft' (i.e. with a definite or indefinite inner margin).

'*Lines*': number; position in the annual increment (early, mid-early, mid-, mid-late, late); broad or narrow; prominent or faint; 'hard' or 'soft' in outline; relationship to the 'autumn band', i.e. free, merging at some points, entirely within it; number of quarters of the circuit present (less than $\frac{1}{8}$ being recorded as O).

This type of record, here used in relation to larch of young to medium age, is applicable to any softwood, but modifications will clearly be necessary for hardwoods. The precise abbreviations used are of no consequence, as other people will no doubt prefer to use their own, but the method is somewhat laborious as it involves the recording of a string of symbols for each annual ring in a tree-section. Its chief advantage lies in the detailed observation and comparison which it

imposes on the user, and it is therefore worth using in obscure cases or at the beginning of work on a new pattern. Its chief disadvantage was found to be that the main features of the pattern were often lost in the mass of detail.

Attention was therefore focused on the 'line' pattern, which was from the first the main basis for identification of the rings, and the necessary simplification was found in recording the frequency of occurrence and position of the 'lines' in each successive year's growth, supplemented where necessary by a note of any other marked characters of the ring. The main features of the 'line' pattern over the period covered by the trees available are given in Table I below:

TABLE I

1940	Mid-line.
1938	Mid-line.
1930	Mid-line.
1929	Mid-late to late line.
1928	Mid-late to late line.
1925	Mid-late close pair of lines.
1923	Late close pair of lines.
1922	Mid-early line.
1921	Hard late line, thin hard band.
1919	Soft mid-late to late pair, sometimes three.
1918	Very prominent mid- or mid-late line.
1916	Late line.
1915	Prominent mid-line.
1911	Hard mid-late line, sometimes also a late close pair, thin hard band.
1908	Two prominent lines, mid-early, and late.
1900–5.	Each year with a strong mid- to late line.

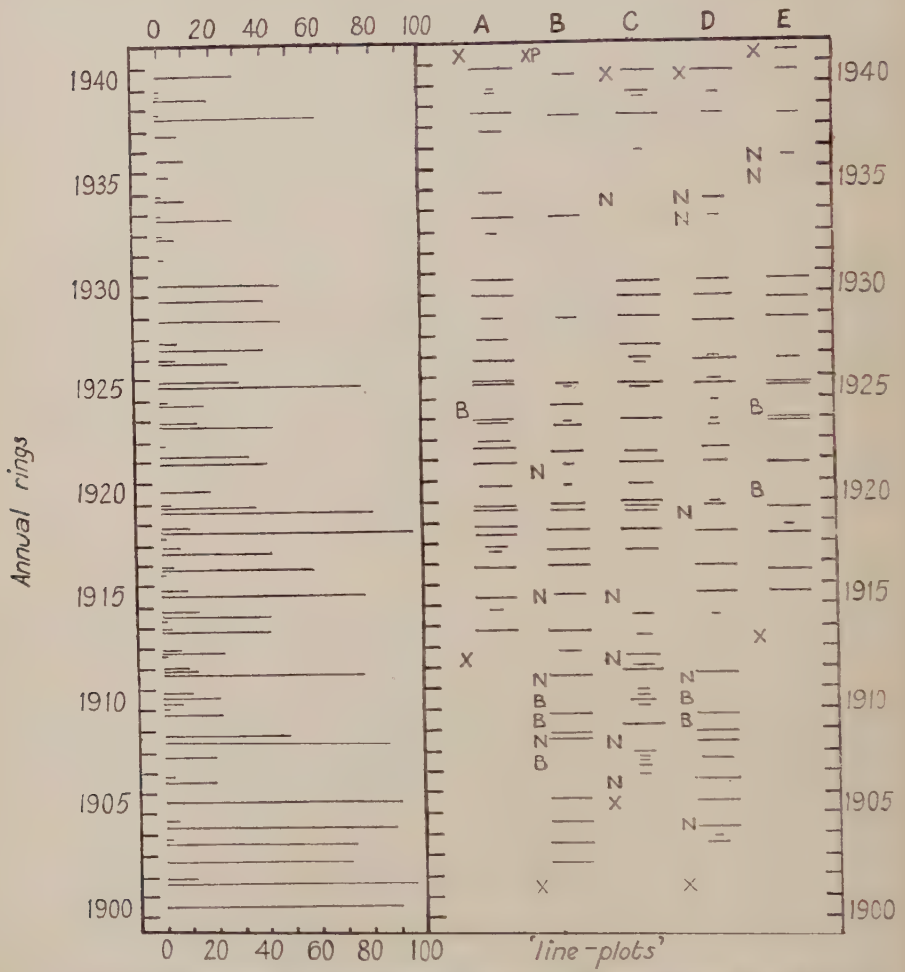
All these features are shown in the plates, but not all of them in any one photograph; for instance, the 1915 'mid-line' shows clearly enough in Pls. VII. 1, VIII. 2, and IX. 1, in which the ring is of normal thickness, but not at all in Pl. VI. 2, and scarcely in Pl. VIII. 1, in which the ring has been partially suppressed.

THE 'LINE' PLOT: THE FREQUENCY DIAGRAM.

Although the crude pattern made by the more prominent 'lines' as given in Table I provides a useful basis for field work, the great variability of the rings often obscures it. No quantitative estimate can be made of the frequency with which these 'main features' occur because there is no way of distinguishing them in practice from others. The only practicable criterion is the visible presence of the 'line', however slight, in the wood, as seen on a carefully smoothed surface with the naked eye or a low-power (×6) lens. Higher magnification, e.g. with the microscope, is less effective as the field is too small and the contrast is lost.

In this way a 'line' plot of a tree section can be made on a strip of graph paper analogous to the 'skeleton plot' used by Glock (4) and others to record the distribution of exceptionally narrow or broad rings. Each 'line' in the wood can be represented by a horizontal line on the paper occupying a corresponding position in the standard space representing the annual ring, and of a length having the same proportion to the width of the 'plot' as the 'line' has to the complete

circuit of the stem. Further refinements are available if desired. The breadth and heaviness of the line can be made to correspond, and characters of the whole ring can be shown by capital letters at the side of the plot, characters of the 'autumn



TEXT-FIG. 4. Frequency diagram showing, on the left, the percentage of 'lines' in each year from 1900 to 1940, based upon 105 butt-sections of European larch, and, on the right, the 'line-plots' of the five trees referred to in Text-fig. 2. Letters to the left of each 'plot' indicate: X—first or last ring of section, B—exceptionally broad ring, N—exceptionally narrow ring, P—partial ring.

band' by lower-case letters. But it is never desirable to complicate the diagram more than is necessary to establish the identification of the rings.

Text-fig. 4 shows, on the right, the 'line-plots' of the five trees from widely scattered localities that were selected for the ring-width measurements shown in Text-fig. 2. It will be seen that there is far more correspondence between the 'lines' than between the relative widths. There is, for instance, no single year in

which all five trees had a markedly narrow or broad ring, but several years in which they all had a pronounced 'line' or no 'line' at all.

On the left of the 'line-plots' in Text-fig. 4 is a diagram showing the percentage frequency of occurrence of 'lines' in European larch from south-west England for the years 1900 to 1940. It is based upon 'line-plots' made from cross-sections of the butts of 105 larches, not all of which, however, covered the first decade of the century, so that the percentages must be regarded as of decreasing accuracy from about 1913 to 1900. This frequency diagram acts as the 'master chart' to which 'line-plots', made on graph paper to the same scale, can normally be fitted in only one position—that which gives the correct dating of the annual rings—double or multiple 'lines', and the gaps in the 'line' sequence, being of particular value in the process.

As accuracy naturally increased with experience some of the more obscure 'lines' may have been missed in some of the earlier records, particularly in those made in the forest, so that there will be a tendency to understatement of their frequency, although this error is not likely to be considerable. It is a matter of observation that the frequency of the 'lines' corresponds broadly with an estimate of their average prominence to the eye. There were no examples of regularly faint or incomplete 'lines' with a high frequency, but there were some conspicuous 'lines' of low frequency. In particular, certain very late 'lines', notably in 1921 and 1916, had a lower frequency than might have been expected from their prominence when present (see Pls. VII. 1 and 2; VIII. 2; IX. 1 and 2). Where these late 'lines' appeared to be missing a more careful examination sometimes revealed a 'double ending' to the year's growth, and sometimes not. It is reasonable to suppose that these 'lines' were lost because the trees stopped growing a little earlier than the others in which the 'line' is visible as a denser zone within the 'autumn band'.

The matching of a 'line-plot' with the frequency diagram therefore often involves no more than matching the spacing of the prominent 'lines' with the years of high 'line' frequency, and especially the series—1911, 1915, 1918, 1919, 1925. If these fit, the remaining features of the pattern almost invariably fall into place; but this process, of course, is helpful only to those who have not yet impressed the pattern on their memory.

The frequency diagram itself is a convenient method of simplifying and presenting the pattern, more accurate in the middle of its range than towards the ends, and with an arbitrary bias in favour of the trees in the northern part of the area (districts I and II) from which nearly two-thirds of the material came. The data are given in greater detail in Table II, in which the 'line' records for the six districts are shown as well as the totals for the whole area.

The fifth column in Table II shows the dating of isolated, missing, and partial rings, general areas of suppression being ignored, and reveals the fact that all the years in which more than one such ring occurred are years of high 'line' frequency. The same tendency is to be seen in the distribution of narrow rings (marked N) in the five 'line-plots' in Text-fig. 4, although in this case a zone of suppression about 1935 in some of the trees has been included. The year 1908 which has two

widely spaced and conspicuous 'lines' has the highest number of missing and partial rings, 5 out of 62 (see Pl. VIII. 1, 2, and 4). The indications are, therefore, that 'line' formation and ease of suppression of the ring are in some way related.

DISTRICT VARIATIONS.

The pattern varies obviously from district to district, from site to site within the district, and from tree to tree within the site. The districts were arbitrarily determined by the distribution of the felling sites and it is quite accidental that they are widely separated and have some measure of geographical existence. Of the six districts, III, V, and VI provided only a few butts each which served to extend the general pattern, district II was represented by 21 trees from one site (White Hill, near Monmouth) out of 26 from five sites. This leaves only two districts which provided enough sections from different sites to allow of some attempt to distinguish the district pattern from that of particular sites dominating it. Of these, district I (37 trees, 7 sites) is on the north Cotswold Oolites, and district IV (23 trees, 7 sites) mainly on shallow soils over Carboniferous Limestone or Old Red Sandstone and Conglomerate, immediately to the west of Bristol.

Table II shows, at the bottom, the 'line' frequencies found for these districts which were as follows in descending order: IV—55, III—43, V—41, II—39, I—36, VI—26. The contrast is great between district IV on shallow soils over hard palaeozoic rocks and district VI on the newer and softer rocks of Hampshire. The intermediate positions of the other districts fit in broadly with the indication that 'line' frequency tends to increase with the age and hardness of the rocks, except where (as in district V) many of the rings are so suppressed as to reduce the number of 'lines'—a point which is considered further under 'Site Variations'. Experience showed that better indications are given by the comparison of selected trees from individual sites than by the inadequate district data available; for instance, the sites yielding trees with the highest and lowest 'line' frequencies were: Three-Corner Wood (district IV) with a very shallow soil over Dolomitic Conglomerate (67 per cent.) and Castle Wood near Warminster (district III) on a fine deep Greensand (21 per cent.). Further comparisons of this type yield similar indications, but the irregular nature of the data, and the many other factors involved, make any detailed analysis impracticable.

The other differences which serve to distinguish the district patterns, if such may be spoken of, are mainly differences in emphasis and in the frequency of certain 'lines'. If the figures in Table II for the districts are compared with the totals on the left it will be seen that there are some pronounced differences between them. In 1930, for instance, over the whole area 46 per cent. of rings had 'lines', but in district I only 8 per cent., in II 76 per cent., in IV 81 per cent. In 1921 the frequencies, taken in the same order, were 41, 11, 60, 83. The general 'line' frequencies are, respectively, 40·7, 36·0, 39·2, 55·0, so that it is clear that these 'lines' are under-represented in district I and over-represented, as compared with the average, in districts II and IV.

It thus becomes possible, by taking all these characteristic features together, to determine from which district a given tree-section comes, provided enough

work has been done to establish the district pattern. The salient characters, for instance, of district I are: a very prominent 1908 pair, with frequent missing or partial rings in that year; frequent 'lines' in 1913 and 1917, a thin hard 'autumn band' but usually no late line in 1921, a single 'line' but seldom a 'double' in 1925, and a poor representation of the usual succession of 'lines' in 1928, 1929, and 1930. As usual the photograph (Pl. VIII. 1) shows some only of these features, not only because a single tree will not show them all, but also because it shows part only of the cross-section.

In district II (mainly the White Hill site, see Pl. IX. 1) there is a tendency to a late instead of a mid-early 'line' in 1922, and 'lines' in 1926 and 1930, but not 1928 and 1929, also in 1938 but not 1939, 1940. The 1918 ring is remarkable at White Hill, having a mid-early 'double' followed by a late 'single' with a broad band of lighter wood between, and this has been noticed elsewhere in the district (at Staple Edge, Forest of Dean).

The peculiarities of district IV (Pls. VI and VII) include a 'double' or 'triple' (Pl. VII. 5) in 1911, a 1914 'mid-line' (Pl. VII. 1), a marked late 1923 'line', often double (Pl. VII. 2 and 3) and resembling that for 1925, and a marked succession of 'lines' from 1927 to 1930 and from 1938 to 1940 (Pl. VI. 3 and 2).

Among the few tree-sections from other districts examined, we may note that in district III only 1 out of 6 trees showed two 'lines' in 1908, and that all the 8 sections from Hampshire (VI) showed a 1916 'line' (Pl. IX. 2).

It is difficult to judge to what extent the district pattern is merely a summation of the effects of local factors—soil, drainage, aspect, exposure, &c.—at the particular sites chosen, but if this is predominantly so one would expect to find the patterns virtually duplicated on similar sites in different districts, and this so far has not been noticed, although separate features of the pattern may be so duplicated, but never in the same combination in one district as in another. Strongly as the site patterns sometimes vary within one district, they seem to retain something in common which might perhaps be attributed to the local incidence of the weather rather than to edaphic or topographical factors.

SITE VARIATIONS.

District IV, between Bristol and the Channel, containing seven sites all within about 2 miles' radius and on several types of geological substrata, offers the best available material for the comparison of site patterns. Table III gives some data based upon a critical re-examination of the tree-sections from this district after further polishing which gave slightly higher values for the line-frequencies than those recorded two years earlier in Table II.

The indications from this inadequate number of trees seem to be that for some reason in this district there is a higher frequency of 'lines' on Old Red Sandstone than on comparable sites on Carboniferous Limestone, and the fact that the highest percentage of all was on a somewhat calcareous Dolomitic Conglomerate suggests that the presence or absence of lime was not responsible for the difference. In contrast, three trees (117 rings) from three different sites in the Brendon Hills (district V) had an average 'line' percentage of only 32·5. These sites were all very

TABLE

	Total, Whole Area 105 butts; 28 sites					*District I (Cotswolds) 37 butts; 7 sites*			*District II (Monmouth.—Dean) 26 butts; 5 sites*		
	No. of annual rings	*No. with 1 or more lines*	*No. with 2 or more lines*	*No. with 3 or more lines*	*Ring missing or partial*	*No. of annual rings*	*No. with 1 or more lines*	*No. with 2 or more lines*	*No. of annual rings*	*No. with 1 or more lines*	*No. with 2 or more lines*
1940	94	27	..	..	..	31	12	..	25	1	..
	,,	18	1	..	..	,,	4	..	,,	4	..
	,,	57	1	..	..	,,	13	..	,,	20	..
	,,	7	..	..	..	,,	1	..	,,	2	..
	,,	9	..	..	..	,,	1	..	,,	1	..
1935	,,	4	..	..	..	,,	..	..	,,	..	..
	,,	9	1	..	..	,,	..	..	,,	4	1
	,,	27	1	..	..	,,	9	..	,,	8	..
	,,	6	..	..	..	,,	..	..	,,	3	..
	,,	2	..	..	..	,,	..	..	,,	2	..
1930	100	46	..	..	..	36	3	..	,,	19	..
	,,	40	..	..	..	,,	6	..	,,	4	..
	,,	47	1	..	..	,,	11	..	,,	4	..
	101	41	7	..	1	,,	8	..	,,	14	4
	102	26	6	..	1	,,	1	..	26	14	3
1925	103	79	32	..	1	37	24	4	,,	21	13
	104	18	2	..	..	,,	8	1	,,	2	..
	,,	46	15	..	..	,,	11	1	,,	10	3
	,,	35	2	..	1	,,	9	..	,,	12	..
	,,	43	1	..	1	,,	4	..	,,	16	..
1920	105	20	..	..	..	,,	8	..	,,	7	..
	,,	83	35	4	..	,,	25	8	,,	23	10
	102	98	10	1	2	,,	34	..	,,	26	10
	,,	43	8	..	..	,,	20	5	,,	7	..
	101	59	4	1	..	,,	22	..	,,	14	4
1915	93	73	8	..	2	,,	24	4	21	20	2
	77	32	11	1	..	,,	7	1	5	2	..
	76	31	2	..	..	,,	21	2	4	1	..
	75	17	4	1	..	,,	4	2	3	..	..
	,,	57	9	5	2	,,	28	..	,,	2	..
1910	70	15	8	5	..	,,	3	1	,,	..	..
	67	15	2	..	..	,,	4	..	2	..	..
	62	54	30	..	5	36	34	24	,,	2	..
	59	12	..	..	..	,,	1	..	1	..	..
	58	11	1	..	..	,,	4	..	,,	..	..
1905	44	40	..	..	..	33	31	..	,,	1	..
	,,	39	2	..	..	,,	30	1	,,	1	..
	41	30	1	..	..	30	24	1	,,	..	..
	34	24	..	..	..	23	18	..	,,	..	..
	25	24	3	..	..	16	16	3	,,	1	..
1900	20	18	..	..	..	11	11	..	,,	1	..
Totals .	3,397	1,383	208	18	16	1,373	494	58	687	269	50
'Lines' per 100 annual rings .	..	40·7	6·1	0·5	..	..	36·0	4·2	..	39·2	7·3

II

	District III (W. Wilts.) 7 butts; 3 sites			*District IV (Bristol W.) 23 butts; 7 sites*			*District V (W. Somerset) 4 butts; 4 sites*			*District VI (Hants) 8 butts; 2 sites*		
	No. of annual rings	*No. with 1 or more lines*	*No. with 2 or more lines*	*No. of annual rings*	*No. with 1 or more lines*	*No. with 2 or more lines*	*No. of annual rings*	*No. with 1 or more lines*	*No. with 2 or more lines*	*No. of annual rings*	*No. with 1 or more lines*	*No. with 2 or more lines*
1940	6	1	..	20	11	..	4	1	..	8	1	..
	,,	..	..	,,	10	1	,,	..	..	,,	..	..
	,,	5	..	,,	16	1	,,	2	..	,,	1	..
	,,	1	..	,,	2	..	,,	1	..	,,	..	..
	,,	2	..	,,	5	..	,,	..	..	,,	..	..
1935	,,	..	..	,,	3	..	,,	1	..	,,	..	..
	,,	..	..	,,	3	..	,,	2	..	,,	..	..
	,,	3	..	,,	6	1	,,	1	..	,,	..	..
	,,	..	..	,,	3	..	,,	..	..	,,	..	..
	,,	..	..	,,	..	..	,,	..	..	,,	..	..
1930	,,	3	..	21	17	..	,,	1	..	,,	3	..
	,,	5	..	,,	20	..	,,	3	..	,,	2	..
	,,	5	..	,,	20	1	,,	2	..	,,	5	..
	,,	2	1	22	16	2	,,	..	..	,,	1	..
	,,	..	..	,,	8	3	,,	2	..	,,	1	..
1925	,,	5	2	,,	22	12	,,	3	..	,,	4	1
	,,	3	1	23	3	..	,,	..	..	,,	2	..
	,,	1	..	,,	20	9	,,	2	..	,,	2	2
	,,	5	1	,,	5	..	,,	3	1	,,	1	..
	,,	..	..	,,	19	..	,,	3	..	,,	2	1
1920	7	2	..	,,	2	..	,,	..	..	,,	1	..
	,,	6	1	,,	21	11	,,	2	2	,,	6	3
	,,	7	..	20	20	..	,,	4	..	,,	7	..
	,,	3	1	,,	12	2	,,	1	..	,,	..	..
	,,	2	..	19	11	..	,,	2	..	,,	8	..
1915	,,	4	1	18	18	1	,,	4	..	6	3	..
	,,	4	4	,,	13	6	,,	2	..	,,	4	..
	,,	2	..	,,	4	..	,,	..	..	,,	3	..
	,,	5	..	,,	7	2	,,	1	..	,,	..	..
	,,	5	..	,,	18	9	,,	2	..	,,	2	..
1910	,,	3	3	,,	9	4	,,	..	..	1	..	..
	,,	2	2	17	7	..	3	1	..	,,	1	..
	,,	6	1	13	9	4	,,	2	1	,,	1	..
	,,	3	..	12	7	..	,,	1	..	0	..	..
	6	2	..	,,	4	..	,,	1	1	..	..	..
1905	3	2	..	4	3	..	,,	3	..	..	..	..
	,,	1	..	,,	4	1	,,	3	..	..	..	..
	,,	1	..	,,	3	..	,,	2	..	..	..	..
	,,	1	..	,,	3	..	,,	2	..	..	..	..
	,,	2	..	,,	4	..	1	1	..	..	..	..
1900	,,	1	..	,,	4	..	,,	1	..	..	..	..
Totals .	242	105	18	712	392	70	150	62	5	233	61	7
'Lines' per 100 annual rings .	..	43·4	7·4	..	55·0	9·8	..	41·3	3·3	..	26·2	3·0

TABLE III

Soil	*Plantation*	*Number of butts*	*Number of annual rings*	*Per cent. with 1 or more 'lines'*	*Per cent. with 2 or more 'lines'*
Shallow over Carboniferous Limestone boulders	Old Hill	9	260	53·5	7·0
Shallow over Carboniferous Limestone boulders	New Forest	3	77	55·8	9·1
Shallow over Carboniferous Limestone boulders	Leigh Woods	1	47	48·7	14·9
Sites on Carboniferous Limestone		*13*	*384*	*53·4*	*8·3*
Shallow over Dolomitic Conglomerate	Three-Corner Wood	2	91	67·0	8·8
Shallow fine sand over Old Red Sandstone boulders	Windmill Hill	4	128	62·5	17·2
Mod. deep sand over disturbed Old Red Sandstone boulders	Yew Tree and Snakeswell	4	117	64·1	16·2
Sites on Old Red Sandstone		*8*	*245*	*63·3*	*16·7*
Whole district		*23*	*720*	*58·5*	*11·25*

exposed, on very steep, shallow, fine, silty sand over Devonian sandstone and shale, and the relative scarcity of 'lines' may be attributed to the partial suppression of many of the rings. A fourth site in the same district on similar soil, but on a gentler slope, yielded a tree with broader rings and 63 per cent. with 'lines'. This may perhaps provide the clue to the differences in district IV, where the survey records show that the more heavily 'lined' trees on Old Red Sandstone were on the whole of better height and girth than those on Carboniferous Limestone, some of which were of very poor girth, especially at Old Hill. It is evident therefore that in any study of 'line' frequency account must be taken of factors (including neglect of thinning) which may reduce the rings to such an extent as to suppress some of the 'lines'; and it was because this could not be done with the data available that further quantitative work was abandoned.

When we come to examine site differences in detail it is clear that many of them are man-made, i.e. determined by the dates of planting and of thinning. Sections can usually be referred to their site of origin within a defined district by these alone. Other site characters may be the unequal growth of the stem on different sides corresponding to the prevailing wind, the occurrence of patches of incipient butt rot (see Pl. VIII. 2) characteristic of certain sites, and sometimes the texture and appearance of the sections, possibly related to the provenance of the trees.

The 'line' pattern itself is distinguished, from site to site, by slight differences in emphasis, in particular by the presence or absence, or different degrees of prominence, of 'lines' in years of medium general frequency (e.g. 1917, 1922, 1926, 1933) and also the number of multiple 'lines' in certain years (1908, 1910, 1911, 1919, 1923, 1925).

For instance, the sites at Old Hill and Windmill Hill (district IV) are suitable for detailed comparison as they occupy very similar exposed hill-sides less than a

mile apart, the first on shallow loam over Carboniferous Limestone, the second on equally shallow, fine sand over boulders of Old Red Sandstone.

The 1911 ring throughout the whole region has a hard, thin 'autumn band' with a mid-late 'line'. At Old Hill four out of nine sections carefully re-examined were found to have in addition at least traces of a late 'double' (see Pl. VII. 5); in the other five there was only a late 'single'. From Windmill Hill only three sections were available, but of these one showed traces of the third line, the others did not. Elsewhere in the district the three lines were not found in these loci, although the late 'single' was occasionally present. That is to say, the occurrence of a proportion of late 'doubles' in 1911 may be regarded as a site character for Old Hill which it shares to some extent with Windmill Hill, but which so far seems limited to that locality, unless or until this same feature is found elsewhere.[1]

It is, of course, impossible to distinguish such neighbouring sites by the 'line' difference alone, at least on the basis of the relatively few trees so far examined. But a reasonable guess at the locality can be made and the planting date determined with the aid of the pattern, except that obscurities in the first few rings may lead to an error of one or two years, which is not very often sufficient to confuse two plantations of the same species in the same district.

These obscurities are no doubt partly due to differing heights of the sections above the ground, partly to the disturbance of transplanting and planting out, and also perhaps to the greater sensitiveness of the seedling tree to environmental factors including those causing defoliation. There are frequently partial and irregular rings in the first few years, but what is most noticeable is the number of 'lines', seldom less than an average of 1 per year for the first 10 years (excluding the first ring as too obscure). Of 10 trees, all of different ages ranging from 26 to 80 years, so as not to cover the same 'line'-sequence, the first 10 years were found to have, altogether, 111 'lines' in the 100 rings. These included 23 rings with 2 or more 'lines'. The general percentages are 41 and 6 respectively. On the other hand, the small number of trunk sections not taken at the base of the tree, and also branch sections, which happen to be available, do not show a high 'line' frequency. It seems clear that the young tree is particularly susceptible to whatever influences are responsible for 'line' formation.

The frequency diagram (Text-fig. 4) shows a general tendency towards reduction in 'line' number with age. The very high percentages shown for the years 1900 to 1905 can be attributed largely to the fact that most of the trees which were being felled in 1940–1, and which were old enough to cover the years 1900–5, were then very young. This influence, of a proportion of very 'young' rings, must have continued to exert a diminishing inflationary effect on the 'line' percentages up to about 1920; thereafter the opposing influence of the narrowing and increasing suppression of the rings would come into play. Apart from this, however, there is no indication that 'line' formation tends to fall off with age after the first few years, so long as the tree is forming well-developed rings; but again the data are inadequate for any firm conclusion.

[1] It has later been found in Douglas fir at Michaelwood, near Berkeley, Glos., and in Norway spruce (*Picea abies* Karst.) at High Meadow Wood, near Monmouth, but not, so far, again in larch.

The pattern is most clearly presented only in the period of maximum ring-development of the tree, which in most plantation conifers is from about the sixth to the thirtieth year of growth; and for this reason the age of a plantation determines very much the appearance of the pattern which trees from that site present. No studies have been made on the effects on the pattern of site factors such as slope and aspect, but this has been largely a matter of opportunity.

VARIATION FROM TREE TO TREE.

Here again the most obvious differences are those caused by the effects of competition between the trees. The width of rings is constantly under the influence of competition and suppression to an unknown extent, whereas the 'line' character is affected by suppression only when it becomes pronounced, and especially when the 'line' is lost in the 'autumn band' or perhaps becomes the 'autumn band' by the earlier cessation of growth. Very strongly suppressed zones were excluded from the records of 'line' frequencies, but careful examination of them usually reveals traces of some of the more important 'lines' in them. The tendency of missing, partial, or very narrow rings to occur in years of high 'line' frequency has already been noted, and this accounts for many of the differences between trees on the same site.

An attempt has been made in Text-fig. 5 to represent diagrammatically the ring-pattern for certain years in the nine tree-sections taken from the Old Hill site (district IV). The small diagram in each square represents one particular annual ring. The base of the square represents the inner boundary of the ring; the upper curved line represents the complete outer boundary of the ring, so that its curvature shows any irregularity in the width of the ring. The extent of the 'autumn band' is shown by vertical shading, and the 'lines' by horizontal broken lines or bands of oblique shading.

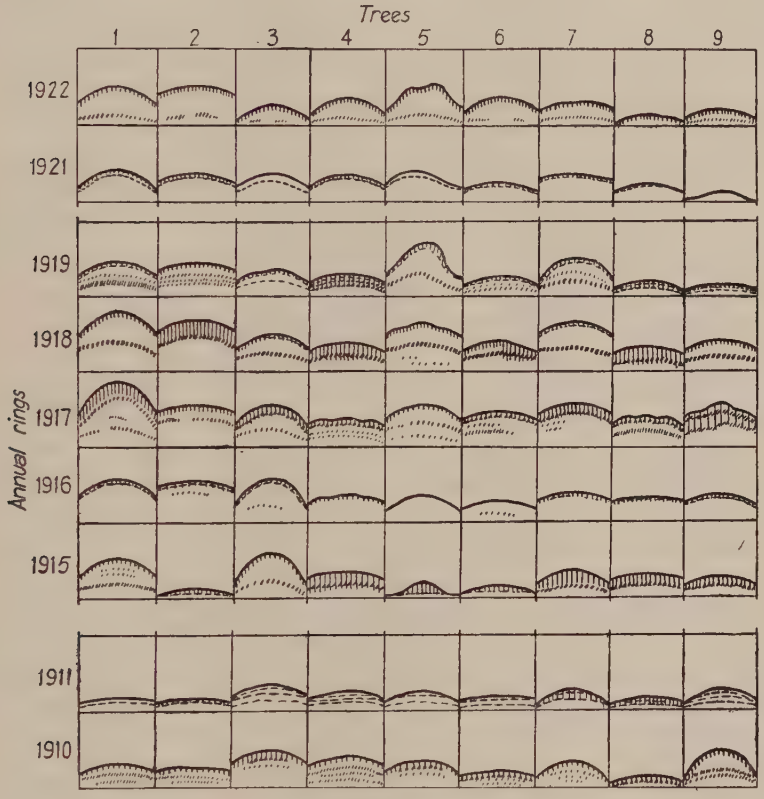
Points which emerge from a consideration of this diagram are:

1. Different seasons show marked differences in the range of variation of the width of the rings, e.g. 1911, 1916 are years of little variation, 1915, 1919 years of great variation.
2. Both the tree and the season seem to influence the extent of irregularity in the width of the individual rings along different radii, e.g. trees 1 and 5 have irregular rings, 2 and 6 more regular rings; 1911, 1921 are years with more regular, 1917 with less regular, rings.
3. The 'autumn band' is of variable thickness, depending more upon the season than the tree. In certain years, 1911, 1921, and to a less extent 1916, it is thin and 'hard' throughout.
4. The 'steadiest' character, offering hope of recognition in a single tree, is the relative position of the 'lines' in the rings, except in cases of extreme reduction, e.g. trees 2, 5, and 6, 1915, tree 8, 1922, tree 9, 1921.

GEOGRAPHICAL EXTENT OF THE PATTERN.

All the material so far referred to in this paper came from the six districts shown in Text-fig. 1, which we may broadly call the Bristol Area. Apart from a preliminary letter in *Nature* (2), publication has been long delayed in the hope that

further work would reveal the geographical range over which the features recognized in this area extend beyond it, but it is now evident that the opportunities given by the war fellings survey are not likely to be repeated, at least so far as the writer is concerned. Sections of the butts of European larch, now about 50 years old, are not easily come by, and younger trees cover only a part of the pattern and need to be studied in greater numbers to establish their relationship to it.



TEXT-FIG. 5

However, a few sections of suitable age have kindly been sent by interested people, and certain features, notably of the 1918 and 1921 rings, have been recognized from sites as far apart as Kent (near Canterbury), Radford Forest (Co. Durham), and North Wales (Nant-y-garth, near Bangor). Of these the section from Kent showed the closest relationship to the Bristol pattern, which could not be said to be recognizable in the material from either of the other two places.

On this flimsy evidence the most one can say is that the Bristol Area pattern does not seem to cover a large part of the British Isles, within which there are possibly several such regional patterns, overlapping and interpenetrating each other. If they have any common basis it must be looked for on very broad lines, in the form of occasional salient features.

OTHER SPECIES OF CONIFERS.

Owing to the early decision to concentrate on European larch the number of sections of other species collected was small except for Japanese larch which provided 19. These presented substantially the same pattern as did the European larch. Years with over 75 per cent. 'line' frequency were: 1908, 1911, 1916, 1918, 1919, 1925, 1929. This shows a greater emphasis on the 'lines' in 1916 and 1929 than in the other species, but that is well within the limits of site and district differences. On the whole the 'lines' are better developed and spaced out in the wider rings of Japanese larch, although their positions in the year's growth may be slightly different. There seems to be no good reason why the two species should not be taken together in further work on the ring-pattern.

As might be expected, the evergreen conifers, with their earlier start to growth (see Hiley and Cunliffe (5)), presented a rather different picture. Douglas fir, with its very broad reddish 'autumn bands', had most in common with the larches. Many of the typical features were strongly shown, but the patterns were difficult to compare with those in larch owing to their 'oversensitiveness', i.e. to the tendency for 'lines' to occur in almost every year, especially at the beginning of the 'autumn band'.

The white wood of the spruces was almost impossible to 'read' in the forest, but after very careful polishing some of the slower-grown sections showed the 'line' pattern in quite typical form, whereas others, especially from faster-grown trees, were practically blank. Finally, the pines were among the least promising of the species examined, mainly because resin and resin ducts largely obscured the details of the rings and were a nuisance in the preparation of good surfaces. But even here typical 'line' features were sometimes to be seen, especially in the heart wood, of which very little was developed in the young trees then being felled.

No attempt has been made so far to extend the work to broadleaved trees, but there seems no reason to believe that a detailed study of any species in a given region would not show that it has its own characteristic pattern, formed by the distribution of the larger and smaller elements within the ring.

DISCUSSION: PRACTICAL USES OF THE PATTERN.

Since this investigation arose in the first place entirely from a desire to overcome the practical difficulties of ring-counting during a survey of felled timber, some reference to its practical uses will be appropriate. The difficulties arose in every case from errors or uncertainties in the identification of the rings, and the main value of the pattern is that it enables the annual growth layer to be recognized, and therefore identified and dated, with a certainty not hitherto available. Not only are obscurities and uncertainties frequently cleared up, but a number of completely unsuspected errors have been brought to light in what had appeared to be quite straightforward ring-counts.

The disadvantage of the ordinary method of counting the rings inwards from the outside of the section is that it gives no clue to the location of missing, or

virtually missing, rings (particularly that of the season when the tree was felled) or of 'false' rings such as the 1918 'mid-line', which was often taken for the limit of an annual ring. Where the rings on the outside or some other part of the section are heavily suppressed, there can be no certainty about ring-counting as there can be no knowing how many rings may be missing in the suppressed zone. But even the most heavily suppressed tree presents the pattern in recognizable form in some part of its ring-sequence, provided only it is of an appropriate age to cover that part of the pattern which is already known.

As pointed out in Part I, the correct identification of the annual increments is an essential preliminary to any valid work on tree rings. The method here advocated, of establishing a pattern whereby the ring-sequence, even in fragmented form, can be *recognized*, is, of course, not free from the possibility of error, but in the writer's experience it gives a degree of certainty not otherwise obtainable.

Apart from detailed research, there are also a number of applications which may be of value to the practical forester. Provided a sufficient part of the pattern at the centre of a stump is preserved, even though the outer rings may be missing, or suppressed, or rotten, it is usually possible to determine the planting date within a year or two; and if the tree has been cut near enough to the ground to show the pith or pith cavity, and it is worth the trouble of polishing the centre rings, or perhaps even of making a microtome section of them, the date of the first year of growth can often be given precisely, and sometimes the dates of transplanting also.

In the same way, if the outer rings are sufficiently preserved, the pattern will give the felling date without much trouble. Years of release from competition by the thinning of neighbouring trees, and sometimes the dates of rabbit scars, butt grazes, and other injuries can be determined.

The dating of isolated missing or partial rings, or groups of such rings, may throw some light on the pathological history of the plantation. For instance, Pl. VIII. 1 and 3 shows photographs of a larch section cut in August 1941 in mid-Gloucestershire (Stanway estate). The pattern revealed that the outer obvious ring was not, as might be supposed, that for the current season, but belonged to the previous year (1940). Pl. VIII. 3 shows the suppressed and partial 1941 ring at its widest point, but at the time it was not found until searched for. Reference to the pathology report on the tree showed a heavy attack of *Coleophora laricella* in 1941.

Only continued observations on thinnings from a growing forest could establish the recognition of the ring-record of such attacks. Light might also be thrown on the effects on the pattern of variations in soil, drainage, and aspect; of management and competition from other species. Before very long it should be possible, after an inspection of cut timber in a yard, to refer at least some of it with reasonable certainty to the neighbourhood where it grew within an extensive forest region.

Finally, it may be said that the unique but fortuitous nature of the material available has made it necessary to put forward many of the conclusions offered in their present tentative form, since the opportunity to confirm them by more detailed work is unlikely to come to the writer; but it is hoped that, among those

who have the necessary continuous access to a forest, and the limited facilities needed for obtaining and smoothing tree-sections, there may be some who will find it worth while to carry the matter farther.

ACKNOWLEDGEMENTS.

Thanks are due to Mr. J. D. Brazier for sending sections of larch from Radford Forest, to Mr. R. E. Parker for a section from Kent, and especially to Mr. W. J. J. Neville for taking most of the photographs and re-drawing most of the text-figures.

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DESCRIPTION OF PLATES.

Note: All the photographs are taken from cross-sections of the butts of European larch trees. The trees marked A to E are the same as those so referred to in Text-figs. 2 and 4. The 1918 'line' is marked with an arrow throughout. (There are also some arrows to other years on Pl. VIII, Fig. 1.)

PLATE VI. Fig. 1 (×⅓) shows the type of material used—a cross-section of the butt of tree C from Old Hill Plantation, near Wraxall, Bristol (district IV)—illustrating a heavily 'lined' tree, 'over-sensitive' in its presentation of the pattern. Even at this reduction the 1918 'line' is clearly visible. Fig. 2 (×⅘). The complete sequence of rings in one part of the same section. The narrowness of the 1915 ring and the irregularity of the 1920 ring are unusual. Fig. 3 (×2). An enlargement of the same sequence from 1918 to 1930, showing the following main features of the pattern: the 1918 'line', a 1919 very late 'line' (but not the two earlier 'lines' shown in the 'line-plot'), the 1921 late 'line' and narrow 'band', a trace of the 1922 early 'line', strong late 'lines' in 1923 and 1925 (but not the 1925 'double' just visible in Fig. 2), a faint but definite 'mid-line' in 1927, and the three strong 'lines' from 1928 to 1930.

PLATE VII. Fig. 1 (×1½). The ring-sequence at Windmill Hill, district IV, 1 mile from Old Hill; a strongly suppressed tree, but showing the characteristic features of the pattern towards the centre (1911 to 1925). Fig. 2 (×2½). The same, enlarged, showing the typical appearance of 1921 in contrast to the other years, also the 1923 late 'double'. Note the contrast in relative widths of the rings in these two figures with those in Pl. VI. Fig. 3 (×7). The 1923 late 'double' further enlarged. Fig. 4 (×3¼). From Staple Edge, Dean (district II), the 1929 late, and the 1930 mid-late 'lines', the latter at first mistaken for a 'band'. Fig. 5 (×4). Old Hill (district IV), the 1911 ring showing 3 'lines', the second more prominent than the 'band'.

PLATE VIII. Fig. 1 (×1). Tree B, from the Stanway estate, district I, shows as much of the pattern as can be presented in one photograph, including the 1902 to 1905 succession of 'lines', the 1908 'double', and at the other end the 1938 and 1940 'mid-lines'. Fig. 2 (×1). For comparison, tree D from the Brendon Hills (district V) at the opposite extremity of the area, despite poor smoothing owing to butt rot, shows many of the same features. Differences are seen in years of moderate 'line' frequency, e.g. 1906, 1913, 1934. Fig. 3 (×4). The suppressed 1941 outer ring in

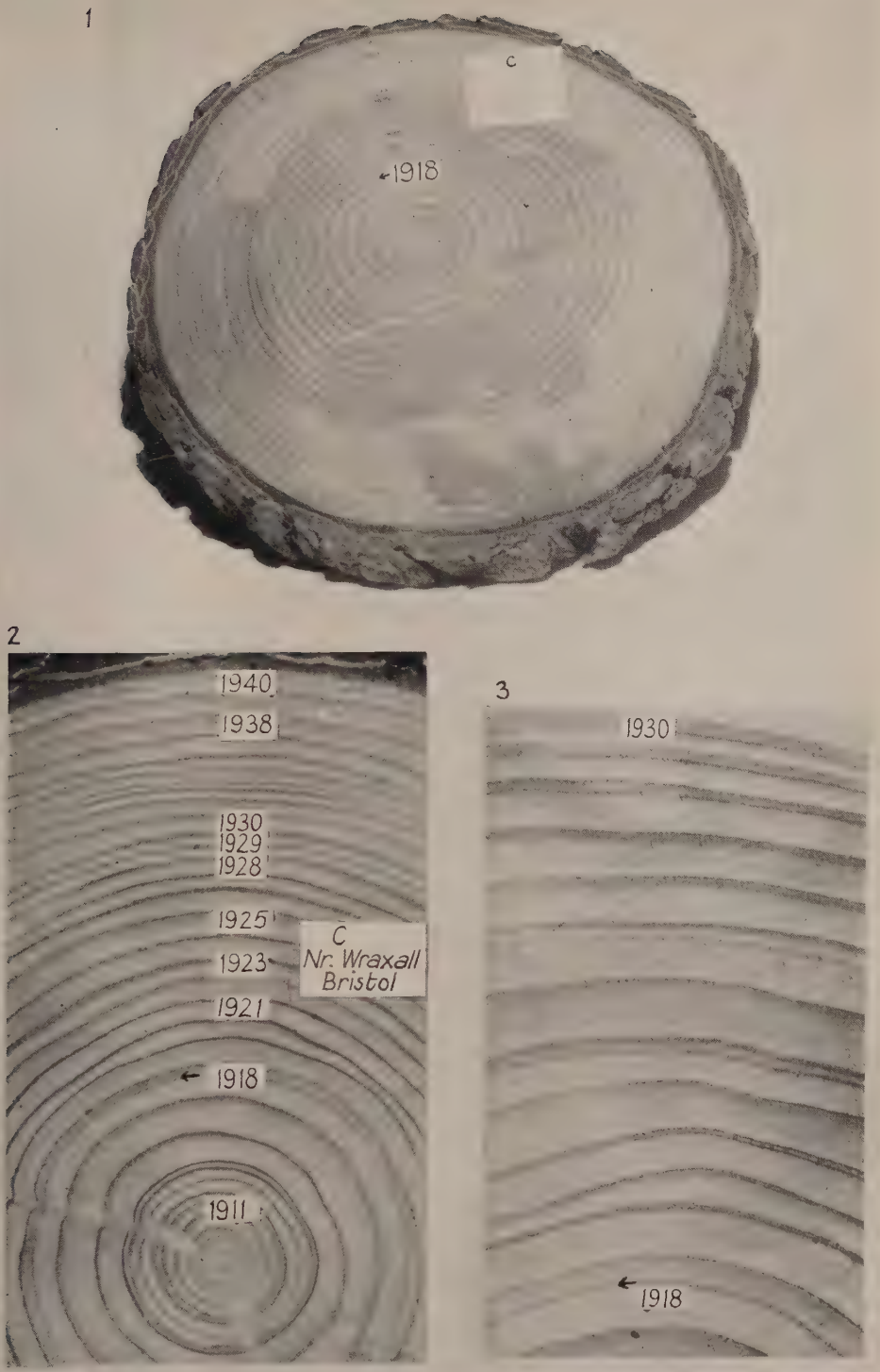
1
C
1918
2
1940
1938
1930
1929
1928
1925
C
Nr. Wraxall
Bristol
1923
1921
1918
1911
3
1930
1918

PLATE VI

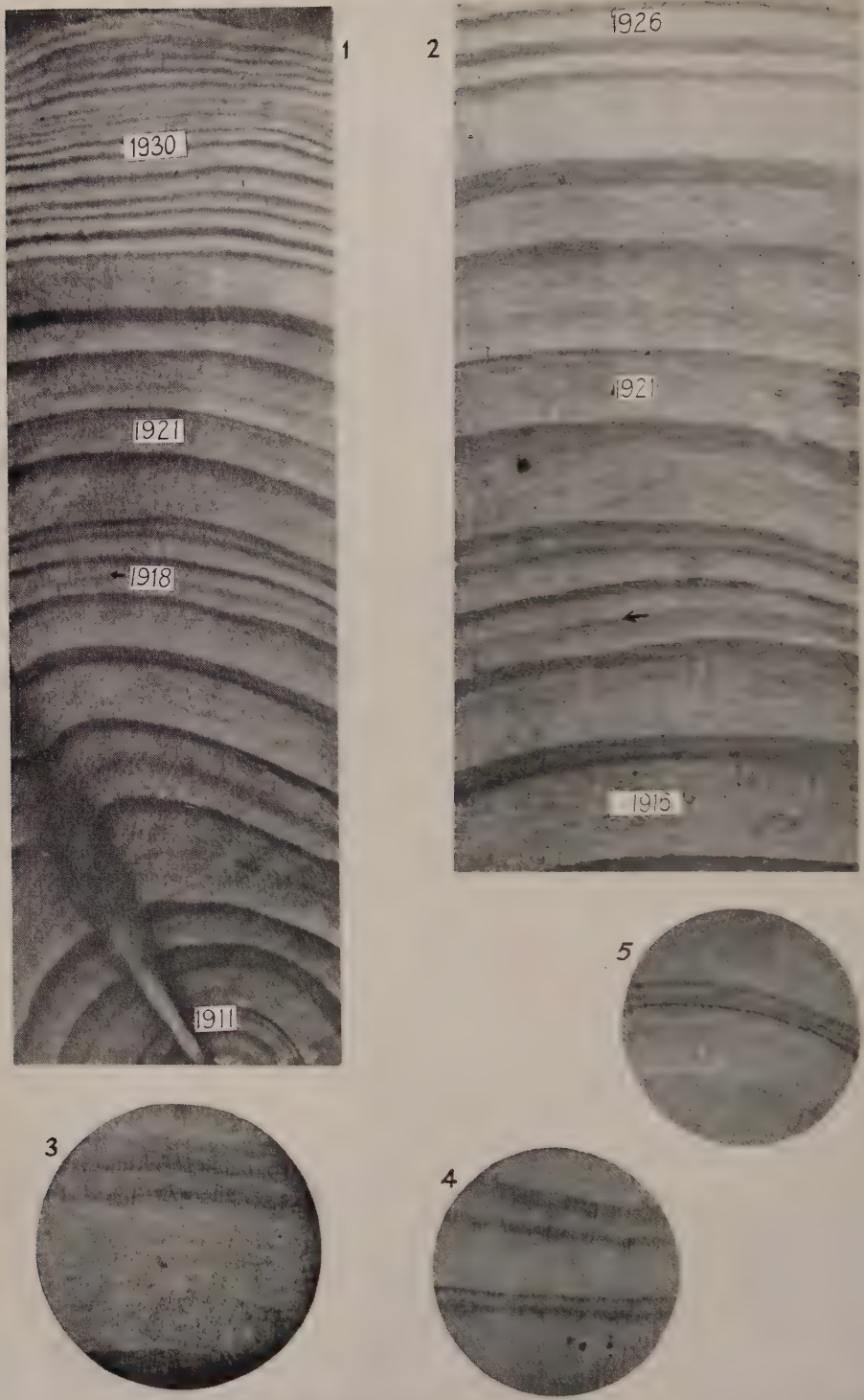

PLATE VII

1
1938
B
Nr. Winchcomb
Glos.
1933
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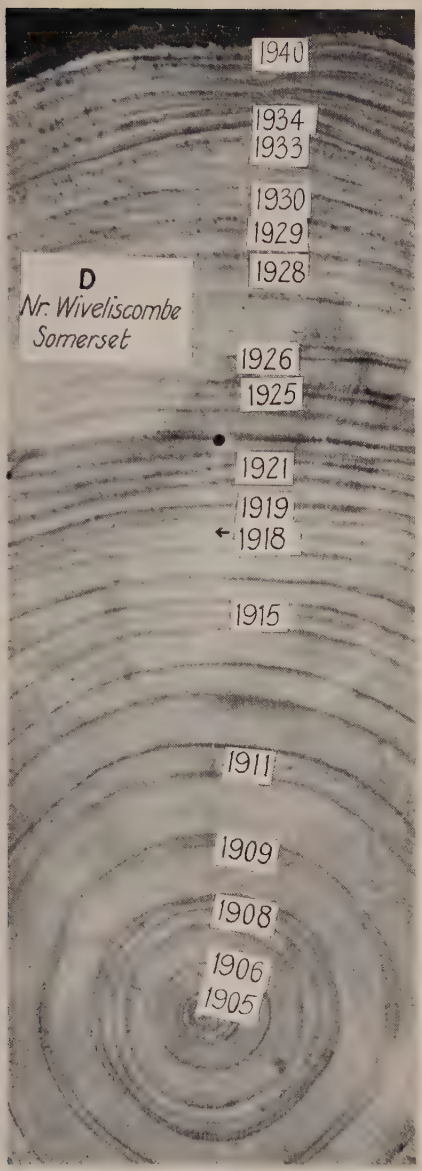
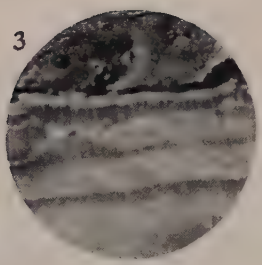
1923
1921
1919
1918
1913
1911
1908
1905
1904
1903
1901


2
1940
1934
1933
1930
1929
1928
D
Nr. Wiveliscombe
Somerset
1926
1925
1921
1919
1918
1915
1911
1909
1908
1906
1905


3

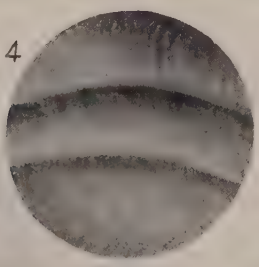

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PLATE VIII

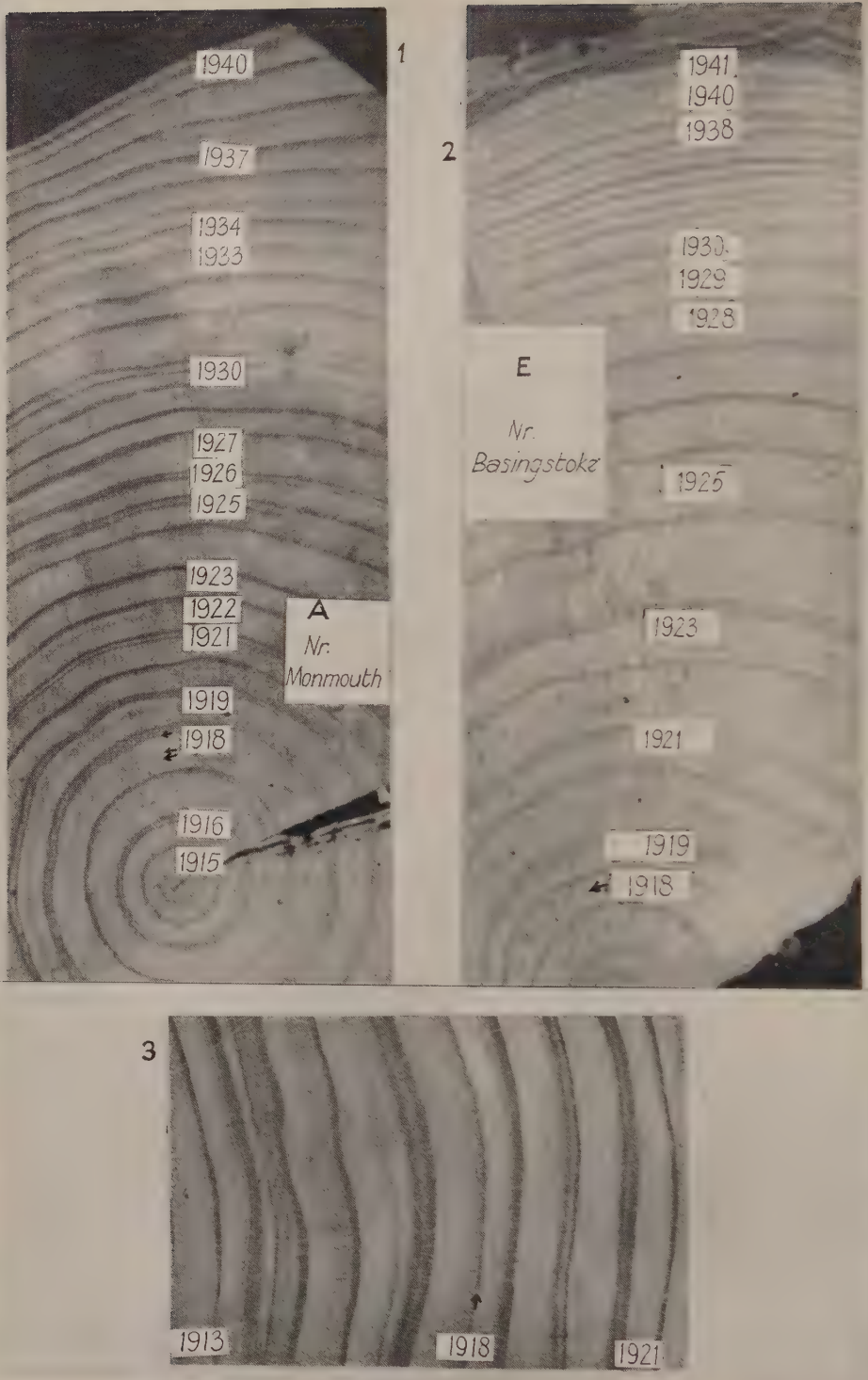
1
1940
1937
1934
1933
1930
1927
1926
1925
1923
1922
1921
A
Nr.
Monmouth
1919
1918
1916
1915
2
1941
1940
1938
1930
1929
1928
E
Nr.
Basingstoke
1925
1923
1921
1919
1918
3
1913
1918
1921

PLATE IX

tree B at its widest point. The 1940 'mid-line' is also shown. Fig. 4 (× 3¼). The partial 1908 ring in another tree from the same site as tree B.

PLATE IX. Fig. 1 (× ¾). Tree A, from White Hill, near Monmouth (district II), showing some of the peculiarities of the site, e.g. the unusual 1918 ring, the mid-late 1922 'line', the late 'lines' in 1926 and 1927, and the 'false ring' in 1930. Fig. 2 (× 1). Tree E shows the main features of the pattern from as far east as Basingstoke (district VI), including the 1923 late 'double' so prominent in district IV (see Pl. VII). Fig. 3 (× 1⅓). The 1913 to 1921 sequence from Colerne, near Bath (district III). The 1918 'mid-line' at first confused the ring-count. Other features of the pattern here are: multiple 'lines' in 1914, a strong 'mid-line' in 1915, a 'double' in 1917, late 'lines' in 1919 and 1920, and a typical hard thin 'band' without a 'line' in 1921.

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NOTE.

Since this has gone to press the attention of the writer has been drawn to the work of Professor Bruno Huber and his associates of the Forstbotanisches Institut, Munich, who have established chronological patterns on the basis of a very large number of measurements of ring-widths. It is evident that the number of timber specimens examined must run into thousands, and that enough material has been available to establish the extent of variation among trees from the same site, which may then be taken into account in estimating the significance of departures from agreement among other specimens. The criticisms of the ring-width method expressed in this paper and in Part I certainly do not apply to this work, which, however, demonstrates the massiveness of the collection of data which has to be made before the method can give reliable results.

C. G. D.

NOTES ON NURSERY IRRIGATION AND ON CHEMICAL WEED CONTROL PRACTICES IN THE U.S.A. AND CANADA

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SUMMARY.

The main purposes of irrigation in American and Canadian nurseries are explained. Information is given on the quantity and quality of water used, the types of pumps required for specific operations, and the types of pipes used in the layout of underground supply channels. Three types of irrigation systems are fully discussed along with the main advantages and disadvantages. The systems described are the flood, the overhead lateral line, and the rotary head sprinkler system. The use of mineral spirits as selective weed-killers in conifer nurseries in America is outlined and the position given with regard to products used, their effectiveness, and quantities and times of application. Figures are given on the costs of the materials along with the costs of application.

IRRIGATION: INTRODUCTION.

WHEN reading American literature on the suitability of sites for forest nurseries it is common to note that an abundant water-supply is usually included high on the list of essentials. This is largely due to the importance attached to water, which forest nurserymen use to great advantage in the production of tree seedlings and for transplants in some of the drier areas.

In practice irrigation is used for five main purposes. These are:

1. To supplement natural precipitation in areas which have a low summer rainfall.
2. To safeguard against unseasonable and prolonged droughts.
3. To reduce soil surface temperatures on excessively hot days in summer. Contrary to the accepted principles of horticulture the shock of cooling even in bright sunny weather is in no way harmful to tree seedlings (2).
4. To thaw out seedbeds prior to lifting in spring when either prolonged frosts or overnight snap frosts preclude the possibility of lifting stock.
5. To soften the ground before hand weeding. At some nurseries the weeding costs are reduced by as much as one-half if the ground is irrigated prior to weeding. In addition the number of seedlings removed during the weeding operation is greatly reduced.

[1] The author visited the U.S.A. and Canada in 1950. As part of the study tour, visits were paid to the following nurseries: Clinton, Tenn.; Marietta, Ohio; Griffith, Hugo Sauer, and Wisconsin Rapids, Wisc.; Waterloo and Bessey, Neb.; Manhatten, Ks.; Wind River and Nesqually, Washington; Saratoga Springs, N.Y.; Duncan, Greentimbers, and Campbell River, British Columbia; Petewawa, Kemptville, and Midhurst, Ontario.

WATER-SUPPLY.

Quantity. For sprinkler systems a source of supply capable of yielding at least 10 gallons per minute for every acre under irrigation is regarded as minimum, and must be available at times of drought. In most instances nurseries are sited on the river terraces of important rivers and the question of sufficiency of water rarely arises, but where supplies have to be obtained from wells, test bore-holes are driven to the water-table or water-bearing strata for measuring the quantities available during drought periods.

Quality. Attention is paid to the quality of water. The supplies must be free from solids and soluble sulphates or chlorides liable to produce toxic conditions in nursery soils, and water containing over 600 p.p.m. of these minerals is regarded as unsuitable for forest nurseries (1). The importance of dissolved minerals in irrigation water is less in northern nurseries where climatic conditions favour a downward movement of solutes in the soil. Contrasted with these, however, are the central and southern nurseries where natural soil water movement in summer is in an upward direction. Here dissolved materials increase in concentration in the upper soil horizons and over a period of years this leads to an over-concentration of harmful salts, if these are present in the irrigation water. The presence of dissolved carbonate or bicarbonate of lime in water supplied to conifer nurseries is an additional highly important factor, because of their effect on raising the pH of the soil. Because of these dangers it is regarded as imperative that irrigation water be analysed at frequent intervals.

The problem of water containing solids in suspension (particularly at times when rivers and streams are in flood) is also given attention and particularly where overhead sprinkler systems are used. Special filtering and screening facilities are provided to meet this problem.

Sources of supply. As already indicated, rivers and streams are the most common sources of supply, with artesian or ordinary wells used as alternatives where surface drainage water is not available. Naturally the former type of supply is preferred because it does not involve the high expense of boring.

Methods of pumping. Horizontal centrifugal pumps operated by electricity or oil engines are used for pumping river-water, and also for well-water where it is available in a gravel stratum within 25 feet of the ground surface. Where underground supplies of water are deeper than 25 feet the more powerful electrical or diesel operated vertical turbine pumps are used (5).

Where the water is directly fed to overhead or sprinkler systems the pumps have to be capable of providing a minimum pressure of 30 lb. per square inch at the most distant overhead oscillators. In the case of horizontal rotary types of sprinklers a minimum pressure of between 50 and 100 lb. per square inch is required.

Direct piping. When the source of water is a river having a steep gradient or large waterfall above the site of a nursery, direct piping of irrigation water from a point upstream can be used to advantage, provided that the head of water is sufficient to operate the oscillators or rotary heads of the irrigation equipment. This method is used at the Wind River nursery, Wash. Although the initial capital

outlay for pipe installation is high, operating costs during subsequent years are low, in comparison with pump-operated schemes.

Screening. Water taken from river sources of water must be free from solid particles in suspension, particularly when the water is used for overhead line systems. The usual method of 'filtration' is to have a deep settling chamber between the river and the pump. These chambers, which are lined with concrete, are 20–30 feet long and 5–6 feet deep. Along their length are fitted between five and seven removable wire mesh screens varying from $\frac{1}{2}$ inch to $\frac{1}{64}$-inch mesh. Periodically the screens have to be removed and cleaned to ensure a free flow of water to the pumps.

Water storage. At some nurseries water is pumped directly into large metal water-towers upward of 100 feet from the ground. These provide a sufficient head of water to operate the oscillators on sprinkler lines, and also assist in raising the temperature of the water before it is applied to the nursery stock.

TYPES OF IRRIGATION.

Flood irrigation. This system of irrigation, although rather antiquated and seldom encountered, is still in operation at the Bessey nursery in Nebraska where it has been in use for 25 years. It can only be used where the ground is level and where there is an abundant supply of water. It is only suitable for irrigating transplant lines.

The system is simple and inexpensive to operate. It consists of an elevated flume constructed of sheet galvanized iron or wood, supported by tubular steel or concrete supports. The cross-section and grade permit a flow of between 4 and 5 gallons of water per second. Facilities for taking water from the channel are provided every 20–30 yards along the flume and consist of concrete circular pipes set into the side of the flume. When the outlets are not required they can be sealed off by metal slides which fit flush with the sides of the channel.

In operation, water is pumped into the head of the flume which carries it to the transplant sections of the nursery. Two or three 6-feet lengths of 10-inch diameter canvas hose are joined together by inserting one end of one section inside the end of the next section. One end of this 'hose' is then fitted over the 'take off' from the flume and bound in position with twine. Water is diverted into it by blocking the flume with a suitable piece of board on the low side of the outlet and opening the metal side cover at the same time. The pressure created by the flow of water down the sectional canvas pipe is sufficient to prevent the section from separating. When the ground in the immediate vicinity of the open end of the canvas pipe becomes flooded to a depth of 1 inch or more, additional canvas sections are fitted to extend the distance of flooding until the entire area under treatment has been irrigated. The operation keeps one man steadily employed moving the pipe extensions from one area to another.

During drought periods each section of the nursery under transplants is given a watering in this manner once every week, and it is estimated that during the operation sufficient water is added to permit downward percolation of water to a depth of at least 10 inches.

In using flood irrigation it is essential that the ground be maintained perfectly level, an essential which requires the use of specialized cultivation and levelling implements. The usual type of farm plough cannot be used for cultivation purposes on the nursery breaks, because the double empty furrow produced down the centre of the break would be a hindrance to flood irrigation by serving as a drainage channel. Consequently ploughing has to be done with a special type of plough which turns out a furrow in one direction only irrespective of the direction of ploughing. This is effected by using a plough fitted with two shares and breasts fixed at 180 degrees to each other and arranged so that one set throws a furrow slice to the left and the other a furrow slice to the right. The two parts are fixed on to a vertical swivel fitted with a locking device so that when one share is working its 'twin' is out of the ground. In operation the plough is drawn down a nursery section and is returned along the same furrow with the second set of shares working, thus producing a series of furrows all lying in the same direction. Normal cultivation practices follow ploughing operations, and after a fine tilth has been produced the section is levelled with a special grader.

The main advantages of flood irrigation are the simplicity of operation and the low maintenance and operational costs. However, there are many disadvantages which far outweigh these factors. They are: the necessity for having a level nursery, the limitation to transplant lines, the heavy leaching of fertilizers through lack of control on the amounts applied, and the necessity of having heavy pumping equipment capable of applying the large volume of water required. Furthermore, the system is too cumbersome for use as a method of cooling in hot weather, and conversely it cannot be used as a method for thawing in winter.

Overhead line sprinkler system. In the United States this system of irrigation is the one most commonly used, and was observed at all but one of the nurseries visited.

The essentials of the system are a water head of over 30 lb. per square inch, an underground distribution system, and an overhead line sprinkler system operated by hand or oscillators. The oscillator method of operation is preferred to the manually operated system because of the more effective and efficient spread of water when being used as a thawing agent. In addition it requires much less supervision.

In the older nurseries the underground water distribution systems are constructed of galvanized iron piping, whereas in recently established nurseries cement asbestos pipes are being widely used. The latter have a threefold advantage over iron in that they are cheaper to purchase, they do not rust and so build up an ever increasing internal resistance to water over a period of years, and they can be rapidly joined together in a matter of a few minutes. The working life of the cement asbestos pipes is guaranteed for 20 years by the manufacturer.

Main underground water pipes and the more numerous side feeds leading to the overhead lateral pipes are laid at depths below the level of winter freezing and well below the depth of soil cultivation. It is usual to find these main 'arteries' running parallel with and alongside the main nursery roads. The diameters of the main pipes vary according to the number of side feeders which they supply, and

consequently as the distance increases from the main water source the main pipe diameters are gradually decreased. A drainage valve is fitted at the lowest point in the system so that the whole underground pipe layout can be drained in winter. Other valves are fitted at regular intervals along the main pipes to control the rate of flow and to divert water-supplies from one part of the nursery to another.

Water is directed from the side feeders into the overhead lateral sprinkler lines by means of 2–3-inch diameter iron pipes which are fitted vertically into the side feeders at a T-joint. These pipes are termed 'risers'.

The lateral overhead lines are sectional pipes up to 400 feet in length and manufactured either from galvanized iron or from one of the new light metal alloys. They are supported at a height of 4 to 6 feet from the ground by tubular steel supports each of which is capped with a special holder in which the lateral line can freely rotate. An elbow-joint makes the necessary connexion to the riser. At a spacing of either 3 or 4 feet along the length of the lateral lines are circular brass nozzles, 100 of which permit a discharge of 22 gallons of water per minute at 30 lb. pressure or 25 gallons at 40 lb. pressure. Given a pressure of 30 to 40 lb. per square inch a single line will irrigate evenly a strip of ground 25 feet wide on each side of the pipe-line; therefore the lateral pipes are spaced at 50-foot intervals throughout areas requiring irrigation. During irrigation operations 10 to 15 lines are operated simultaneously, the actual number being governed by the amount of water available.

As in the case of the underground pipe systems it is essential to maintain an even pressure of water throughout the length of the pipe, and this is achieved by decreasing the diameter of the pipe with increased distance from the supply end. For instance, a 250-foot line with a 3-foot nozzle spacing would be constructed of 80 feet of $1\frac{1}{4}$-inch piping, 100 feet of 1-inch piping, and 70 feet of $\frac{3}{4}$-inch piping. In the case of a 400-foot line (which is regarded as the maximum length) the composition would be 120 feet, 120 feet, 100 feet, and 60 feet of $1\frac{1}{2}$-inch, $1\frac{1}{4}$-inch, 1-inch, and $\frac{3}{4}$-inch diameter piping respectively. Using a 4-foot spacing of nozzles on a 400-foot line the section would be made from 160 feet, 160 feet, and 80 feet of $1\frac{1}{4}$-inch, 1-inch, and $\frac{3}{4}$-inch diameter piping respectively.

Hydraulically operated oscillators are fitted between the end of the lateral line and the riser for rotating the lateral line through an arc of 180 degrees. Various types are on the market, but forest nurserymen usually select either one of two types, viz. 'Whiteshowers' or 'Skinner'. Both are efficient, but the former is much brisker in action. A brief timing study at Wind River nursery shows that when working at maximum capacity the 'Whiteshowers' type completed one arc of 180 degrees in 0·75 minute, whereas the 'Skinner' type took 3·6 minutes.

In spite of the initial high cost, this type of irrigation has a great deal to recommend it. It gives excellent coverage under ideal weather conditions, and it does not favour heavy leaching of soil nutrients as in the case of flood irrigation. It is simple to operate and can be used on ground which is not necessarily level. The main disadvantage is that because of the very fine spray it is difficult to get even coverage when the wind velocity is over 3 m.p.h., and when air temperatures

are high and atmospheric humidity low up to 50 per cent. of the water can be lost in evaporation before the water reaches the ground.

Sprinkler system using rotary heads. These systems are common in Canadian nurseries. They were not seen in the U.S.A.

The essential parts of the systems are very similar to those required for overhead line sprinklers. They are an adequate water-supply, a pressure head of between 50 and 100 lb. per square inch (as against 30 lb. for overhead lines), underground main conducting pipes, lateral side feed pipes, and the risers. The rotary head is the main variant between the two systems.

Various designs of rotary heads are in use, and most of them depend upon simple turbine action for their motion. Working with pressures of 75 lb. per square inch and with the rotary heads 3 to 4 feet above the ground it is usual to obtain adequate water coverage over a radius of 25 feet. In practice, twelve watering heads are used simultaneously, and are operated from risers spaced at 50-feet intervals along main paths. Risers are staggered in alternate rows (which are 25 feet apart) in order to give full water coverage. After operations in one area have been completed, the rotary heads and riser connexions are removed and transferred to the next site to be irrigated.

The efficacy with which each type of sprayer gives even coverage of water over the whole area which it serves is very variable. A sprinkler of the 'Rain Bird' type was generally recognized as the most efficient. It consists of two arms fitted with nozzles which are adjustable to give differential radii of water spread, with relatively even coverage. In addition the jets can be regulated to give a range of 'precipitation' varying from $\frac{3}{8}$ inch to 1 inch per hour. Unlike most rotary heads the head is rotated in several distinct phases, this being done by means of a hydraulically operated device which hammers the head through an angle of approximately 6 degrees every second.

Rotary sprinklers are quite satisfactory for nursery irrigation work, because they can operate on undulating ground and also, because of the relatively wide nozzle, water containing small particles of solids is no serious problem. The system is suitable for both seedbeds and transplant lines, and operates well in winds up to 5 m.p.h. In addition because of the larger droplet size there is less evaporation between the time the water leaves the sprayer and reaches the ground. The chief disadvantage is that in getting entire coverage double watering on some part of the ground is unavoidable.

Rate and time of watering. The rate of application at any one time for irrigation purposes usually amounts to a sufficiency of water to percolate to depths of 6 to 8 inches. Experience over a period of years at individual nurseries leads to an intimate knowledge of the soils, and the amount of water required at any time can be judged by knowledge of recent weather conditions, the time of the last rain, or previous artificial application of water. Wilde (6) points out that, provided irrigation does not lower the soil aeration by more than 20 per cent. by volume for any considerable length of time, there is no danger from reducing processes in the soil.

Watering usually begins from the time that the seed is sown until early autumn.

The practice is stopped a few weeks before the first early frosts take place in order to enable the seedlings to 'harden off' (3). It is recognized that very early morning (before sunrise) or late evening applications are the most suitable. In practice, however, this is not generally feasible, and therefore it is usual to irrigate throughout the whole day.

MINERAL SPIRITS USED AS WEED-KILLERS.

Within recent years in the United States, mineral spirits have been used effectively as selective weed-killers in conifer nurseries. The spirits are of naphthenic origin and have an aromatic hydrocarbon content of between 10 and 20 per cent. by weight. They are a by-product of the petroleum industry and in America are marketed under the trade names of Stoddard Solvent, Sovasol No. 5, Varsol, Stanisol, &c.

The spirits are applied to conifer seedbeds as both pre-emergent and post-emergent sprays. In the case of the former it is considered safe to apply 100 gallons of spirit per net acre of seedbeds immediately before the seedling cotyledons appear above the ground. Normally an examination of the seedbeds is made to determine when the radicles of the seedlings are just beginning to emerge. This stage of development is regarded as optimum for the operation. The spray treatment is quite successful in controlling weed-growth for the first 3 to 6 weeks after sowing.

Post-emergent sprays, which take place after the tree seedling cotyledons have appeared above the soil surface, vary in volume according to the species and age of the stock. They take place when required at times dictated by the size and abundance of small weeds. For tender conifers (non-deciduous shade-bearers and intermediate shade-bearers) the first post-emergent sprays are in the order of 25 gallons per acre, but as the seedlings increase in age up until the beginning of July, the amounts are gradually raised to a maximum of 50 to 75 gallons per acre. Most intolerant light-demanders such as pine can withstand dosages of 50 gallons per acre within a few weeks after germination.

In practice the spirits are applied as a *very fine* mist spray. Various types of machines are available for the operation and most of them consist of a container for the spirit, a pump for creating a pressure of approximately 100 lb. per square inch within the container, and a spraying unit comprised of a pipe and two booms suitably fitted with nozzles to create the fine mist and capable of spraying three seedbeds simultaneously. This equipment is mounted in front or behind a tractor, or is hauled behind a tractor on a special carrier. Applications using the spirit at full strength are normally used, but some nurserymen consider it safer and equally as effective to use an emulsified mixture of spirit and water.

Most of the common conifers used in America have been tested for tolerance to the spirit, and in the northern nurseries, where heavier applications are less damaging to conifers than in warmer southern nurseries, the following species have withstood dosages of 50–70 gallons per acre when treated in ideal climatic conditions after the end of June: Scots pine, *P. sylvestris* L.; Jack pine, *P. Banksiana* Lambert; Red pine, *P. resinosa* Aiton; Austrian pine, *P. nigra forma*

austriaca Aschers and Graebner; White spruce, *P. glauca* Voss; Norway spruce, *P. abies* Karst; Silver fir, *A. balsamea* Miller; and Douglas fir, *P. taxifolia* Britton. Larch (*Larix* spp.) is the only main group which provides an exception because it is subject to heavy mortality and severe damage at all stages of development in summer.

The reaction of mineral spirits on most dicotyledonous and monocotyledonous weeds is very rapid. Within a few hours after application the weeds begin to show signs of wilting, and after 24 hours most of them are dead, the foliage having turned grey to buff in colour. Using an application rate of between 50 and 75 gallons per acre the range of weed-kill is from 60 to 95 per cent. depending on the species of weed and the stage of development. Small weeds in the cotyledon stage of development are much more susceptible than when they are mature. Certain plants, particularly perennials, are difficult to kill with dosages which are not harmful to conifers: couch grass (*Agropyron repens* Beauv.), thistles (*Carduus* spp. L.), clovers (*Trifolium* spp. L.), and groundsel (*Senecio vulgaris* L.) are among these. Hence a light hand-weeding is usually necessary after spray applications of mineral spirits in order to remove these resistant species. Even including the supplemental hand-weeding, the use of mineral sprays in conifer nurseries has reduced weeding costs from 50 per cent. to as much as 95 per cent.

The value of the spirits is greatest in first-year drill-sown seedbeds, when the use of the mechanical cultivation and hand-weeding is precluded by the small size of the seedlings from the first two months after germination. In 1950 the mineral spirits cost from 1*s*. 4*d*. to 1*s*. 8*d*. a gallon, and the cost of application varied from 15*s*. 6*d*. to 33*s*. 6*d*. per acre using a power-operated spray. Total weeding costs per acre were from £5 to £6. 10*s*. for spraying, according to dosage rates, with an additional charge of from 30*s*. to 140*s*. per acre for supplemental hand-weeding. Weeding exclusively by hand cost from £30 to £50 for a single weeding.

In 1948 Stoeckler (4), working at the Hugo Sauer nursery, Wisc., found that when applying mineral spirits to 1+0, 2+0, 2+1, and 2+2 stocks of conifers, less damage was caused to the plants if an application of water is given immediately before applying the mineral spirits. In addition it was observed that better results were obtained when spraying was confined to periods of cool weather, at night, or to trees growing under shade.

There has been no evidence produced so far to support the view that mineral spirits have an adverse effect upon nursery soils.

ACKNOWLEDGEMENTS.

I wish to express my thanks for the help and hospitality given to me by many members of the staff of the U.S. Forest Service, State Services, and others in the U.S.A., and also to members of staff of the Forest Services of British Columbia and the Dominion of Canada. The first arrangements in the U.S. were made by Mr. J. H. Stoeckler, of the U.S. Forest Service, Rhinelander, Wisconsin, to whom I am deeply indebted.

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FORESTRY, VOLUME VII, NUMBER I

The Publishers have need of a few extra copies of this number of *Forestry* to make up for a packer's error of some years ago which has left them uncomfortably short. They would be very glad to purchase any copies which members or subscribers may have to spare, and anyone willing to supply a copy or copies is asked to write to The Secretary to the Delegates, The Clarendon Press, Oxford.

AN OUTLINE OF FRENCH SILVICULTURAL LITERATURE

By G. D. KITCHINGMAN

SUMMARY.

The principal authors from the seventeenth century onwards and their works are discussed briefly as a guide to the study of the subject in the original language.

IN this article I shall limit myself to some notes on the principal silvicultural classics of France. Not forestry; only silviculture. Consequently I shall exclude books on policy, mensuration, protection (although this is often treated in text-books on silviculture), utilization, forest law, &c. The notes are intended as a guide for those who read French and wish to study the development of silviculture in France in the originals.

SEVENTEENTH AND EIGHTEENTH CENTURIES.

From the enormous amount of forest literature published during the nineteenth century in German one might easily imagine that the first silviculturists were Germans. But they were not. German silviculture began with G. L. Hartig's *Anweisung zur Holzzucht für Förster* which did not appear until 1791, whereas during the eighteenth century the French were well ahead of the Germans and their silviculture the best in the world.

Between the Ordinance of 1318 and Colbert's Ordinance of 1669 they had gradually developed a system of high forest with natural regeneration from seed-bearers which became known as the *tire et aire*. In this method, which became generally adopted in France under the terms of the Royal Statute of 1669, 'equal areas of forest were cut over successively in the order in which they followed each other on the ground, a fixed number of trees were reserved per acre, and the young crops that came up were left to themselves and grew on untouched for the whole length of the rotation adopted'. There has been quite an interesting controversy about how many of the French forests were managed by this *tire et aire*, and the two best references to this controversy are *Une Légende forestière* by Reuss in volume vii (1935) of the Nancy *Annales*, and a small book by Blais called *Une Grande Querelle forestière: La Conversion* (Paris, 1936). A complete translation of the ordinance will be found in the *French Forest Ordinance* by J. C. Brown (Edinburgh, 1883).

In 1721 the naturalist Réaumur recommended the conversion of coppice to high forest by a system of thinnings, and he was the first (before any German) to think of the yield in terms of volume instead of trees.

In 1739 Buffon advocated the natural regeneration of coniferous forests by leaving 40 to 50 seed trees per acre. But of the eighteenth-century writers probably the two best remembered are Duhamel du Monceau (1700–82) and Varenne de Fenille (1700–93). The former is generally considered the founder of scientific forestry in France, and his *Traité complet des bois et forêts* published from 1755 to

1767, and his *Semis et plantations* published in 1780, were the writings of a woodland owner who had studied and practised forestry all his life. He is said to have been the first to arrange the felling sequence against the direction of the prevailing wind. Varenne de Fenille was a Conservator of Forests and also a writer; his two memoirs on the treatment of coppice and of high forest (1790 and 1791) were important contributions to literature. Huffel says of him that he developed the theory of thinning to almost the stage in which it was a hundred years after.

NINETEENTH CENTURY.

With the Revolution the Forest Service was disbanded, and it was not until 1824—when the Forest School at Nancy was established—that the science of forestry in France breathed again.

Shortly afterwards, in 1827, it received a splendid impetus from the famous *Code Forestier*—which partly revised the Ordinance of Colbert that had been in force then for over 150 years. Bernard Lorentz (1775–1865) was the founder and first director of the school at Nancy. Like several other forest officials he had had to flee to Germany at the Revolution, and he lived there for 8½ years, becoming imbued with the teachings of Hartig. Hartig in Prussia and Cotta in Saxony (*ces deux princes de la sylviculture allemande*) were the first Germans to give a scientific form to the silvicultural ideas that had been rather 'in the air' during the previous century in western Europe, particularly those concerning natural regeneration. On his return to France Lorentz fought with the administration to introduce the high-forest system with its periodic blocks, periodical thinnings, and regeneration fellings. At the same time he violently attacked the coppice-with-standards system—then the traditional and prevalent method of treatment throughout the country. He condemned it as pursuing two objects on the same piece of ground, i.e. the production of timber and the production of coppice. In fact he once described himself as the 'enemy of coppice'. In collaboration with Parade (1802–65), who was teaching silviculture at Nancy and had studied at Tharandt under Cotta, he produced the *Cours élémentaire de Culture des Bois* which first appeared in 1837. (Actually most of the book is said to have been written by Parade.) This famous textbook ran into six editions (the last in 1883 by A. Lorentz and L. Tassy) and was undoubtedly the most important manual of silviculture in France during the nineteenth century. This classic, recording the teachings of Hartig and Cotta, is divided into six books which cover the general theories of the science as then known. The fifth book is perhaps the most interesting as it expounded for the first time questions of political economy, e.g. the relations of the State and communal forests in the timber resources of the country; the value of long rotations in building up reserves of timber, and the felling of forests considered firstly in relation to the needs of the forest owner and secondly in relation to the soil and climate. *Production soutenue, régénération naturelle, amélioration progressive*: these are the keynotes of this classic.

An excellent little book of pure silviculture, intended for the use of foresters, was written by Bagneris in 1878 and called *Manuel de sylviculture*. It is better known than most books of this time because of an English translation by two

officers of the Indian Forest Service (Fernandez and Smythies) which was published in Nagpur, in India, in 1876 and in London in 1882.

Charles Broillard (1831–1910) was a teacher at Nancy from 1865 to 1878, and from 1892 to 1903 editor of the *Revue des Eaux et Forêts*. His most notable book, written in strong and clear style, was *Traitement des bois en France à l'usage des particuliers* (1881–94). It was a general textbook of silviculture, written especially for the private woodland owner, and was for long the standard work of its kind. He did not believe in a pedantic application of mathematics to forestry, but held that although of course they were in a general sense necessary, yet the conditions of the soil, aspect, situation, and many other factors are so infinitely varied that too much should not be expected of mathematics. 'Les mathématiques trompent en sylviculture et les équations ne livreront jamais le secret de la forêt vivante.' A forester should never cease to watch and observe.

The next milestone in the course of silvicultural literature was Boppe's *Traité de sylviculture* in 1889. Lucien Boppe (1834–1907) followed Bagneris as Professor of Silviculture in Nancy in 1881, and followed Puton as Director from 1893 to 1898. He had much experience in the broadleaved forests, especially in the Lorraine plain, and was an expert in the conduct of those delicate operations which concern the conversion of coppice-with-standards to high forest. In his *Traité de sylviculture* (1889) he set forth in the clearest and most instructive manner the French methods of treatment. Although not the inventor of the *éclaircie par le haut*, he did more than anyone to put it in practice in France, and his book contains perhaps the most lucid presentation of the theory of this type of thinning to be found in forest literature. Underlined is 'En un mot, à tous les âges du peuplement uniforme, le respect scrupuleux des étages intermédiares et buissonnants est la base fondamentale de tout système d'éclaircie'. His other book, *Les Forêts*, published in 1900 in collaboration with Jolyet, was based on his lectures at Nancy. It follows the usual pattern: first a part dealing with the tree as a tree, then notes on species followed by descriptions of the silvicultural systems used in France. It was not displaced as the best textbook until Jolyet revised it in 1916. It may be of interest to recall that Boppe has a link with the British forester because, in recognition of his eminent services in connexion with the training of candidates for the Indian Forest Service, he was made a Companion of the Indian Empire. In 1881 Boppe brought his students, and some teachers also, to Great Britain on a tour. At page 196 of volume xi (1887) of the *Transactions of the Royal Scottish Arboricultural Society* will be found his report on Scottish and English forests.

TWENTIETH CENTURY.

Another book on silviculture was written about this time by Fron. It was a small work, and like Broillard's addressed to the landowner and the farmer. It gave a clear account of general silvicultural principles with special emphasis on methods of artificial regeneration and tending. There were two editions, one in 1903 and a second in 1909.

I now come to Huffel, one of the most talented writers of French forestry.

Gustave Huffel (1859–1935) spent no less than 37 years (from 1888 to 1926) at Nancy. Very early in his career he had been sent to Roumania, and the brilliant report that he wrote of his mission there and the several articles he had written in the *Revue des Eaux et Forêts* attracted the attention of the administration and marked him as an outstanding forest economist with great literary gifts. He had also a very perfect knowledge of German. There was no surprise therefore when, at only 29 years of age, he was appointed Professor of Forest Economy and Management at Nancy. Although primarily an *aménagiste*, his writings cover almost every phase of French forestry; and he had a marvellous gift of describing complicated calculations in quite simple words, for he always preferred curves and graphs to rows and columns of dry numbers.

His principal work, now a classic and one to be recommended as the best introduction to French forestry, is his *Traité d'économie forestière* in three volumes. The first edition appeared from 1904 to 1907, and the second from 1910 to 1926. As this work is so important I shall discuss in some detail those parts which interest silviculturists, and from the second edition which revised and enlarged the first very considerably. The work is not at all like the usual textbook but is a collection of independent essays—each essay complete in itself. The first volume, which in the second edition came out in two parts instead of one, contains four essays. In the first essay, dealing with the direct and indirect values of forests, the chapters on the effect of forests on the climate, on springs, and on floods and in Protection forests are of great interest. That on springs has been translated in full by Woolsey as Appendix A to his *Studies in French Forestry*. The second —a history of forest ownership and legislation—is a monumental piece of writing; 266 pages devoted to a detailed account of old law texts and historical documents from Gallic, i.e. Roman, to modern times! A wonderful picture of woodland ways in primitive times. And the picture that Huffel gives us is based not, as so often, on legends, but on a patient study of official documents in the original. I find particularly interesting the account of the origin of the communal forests, and of how those belonging to the Kings of France and the Church were administered. The whole of this study is richly and precisely documented, with fascinating notes on the origin of many forest terms that are still with us. The third essay is called *Politique forestière*, and it describes attempts in France to improve the law regarding Protection forests and tells of the poor condition of private woodlands in the country and the need for increasing the area under State forest. In the last chapter the author gives his own views on the thorny and difficult question of forest taxation and import duties. The fourth, and last, essay in the volume gives us the forest statistics of France and her colonies for 1917 (approximately). A few figures pertaining to silviculture are worth mentioning. The forests of the country covered 9–10 million hectares, about 19 per cent. of the country. In the State forests (12 per cent. of the forested area) 59 per cent. were under high-forest systems, 29 per cent. under coppice-with-standards, and 3 per cent. under simple coppice. The remaining 9 per cent. was under conversion to high-forest. The question of conversion fills a large place in French silviculture, and the methods used have been fully described by Troup

in his *Silvicultural Systems*. But the areas taken up each year for conversion became less and less after about 1890 when criticisms arose. Only one-quarter of the forests are under conifers, three-quarters being under broadleaves—mostly oak and beech. The second volume (first edition 1905; second edition 1919) deals with Mensuration, Statics, and Valuation. By the use of graphs to depict the stand instead of cumbersome unintelligible tables, and with clear and concise descriptions, these intricate mathematical parts of forestry are very much easier to understand than in those dry and tedious textbooks from the other side of the Rhine. The methods in vogue in France, and many a 'short-cut' (empirical) formula—so useful in practice—for calculating the volume of stands, are clearly described. And there is a particularly concise account of the effect of thinnings on increment and volume production. There is no affectation about this volume; no vague theories and hazy formulae: nothing but precise facts easily understood. In volume iii (first edition 1907; second edition 1927) we meet Huffel the *aménagiste*. After dealing with the advantages of working plans and a steady annual yield he goes on to discuss the various ways of calculating a yield, and then gives us a very full account of the beginnings of forest regulation in France in a history of the old and many modern methods of management. Silviculturists will probably find the chapter dealing with the policy of the 'quarter in reserve' the most absorbing, for this is now the standard and most authoritative account. French foresters are very conservative in their management policy and attend more to the silvicultural aspect of the question than to obtaining the highest pecuniary return; and they prefer to grow the kind of timber most needed to that which might be more profitable. Hence they attach great importance to this reserve of one-quarter of the yield, allowing only three-quarters of the total annual yield to be distributed or sold, the remaining quarter being left to accumulate and form a reserve fund or stock of timber from which exceptional necessities in the way of wood or money can be met.

Huffel was a good historian and did more than any other writer to interest other countries in the science of forestry as practised in France. In the field of silviculture he was largely responsible for popularizing the selection system and the *coupe unique*; and he was definitely the originator of the *futaie claire*. In his retirement he kept in touch with the progress of forestry and continued to write regularly for the journals, specializing in reviews of works written in German.

Another silvicultural writer about this time was Jacquot (1856–1944). His *Incendies en Forêt* (Paris, 1904), which was translated into English and German, is still the standard book on the valuation of the damage to forests by fires. The English translation is by Fischer, and was published in Calcutta in 1910 under the title of *Forest Fires*. In 1911 he published a delightful little book called *La Forêt*, in which he described the economic, physical, and social importance of forests. His critics said he exaggerated, but, if we remember that it was really a series of lectures given to public audiences, we can easily pardon his picturesque language.

But his best work is his *Silviculture*—a practical manual for woodland owners

and schools of agriculture—of which the first edition appeared in 1913 and the second in 1931. I have a 'soft spot' for Jacquot because this book of his was the first French forestry book I really studied. As the forest officer at Tronçais said in 1920, when he recommended it to me, it is written in a style *élégant et précis*. The title is misleading, as it is really a small encyclopaedia covering the whole ground of forestry in a general way. Jacquot was also then an authority on the afforestation of bare lands and the introduction of Scots pine on poor quality land. He was a well-informed man, a sportsman, and a real out-of-doors forester who lived to a ripe old age to become the doyen of the *Corps forestier*.

The best textbook today is without a doubt that of Jolyet's which came out in 1916. Jolyet (1867–1942) had collaborated with Boppe, as mentioned above, in *Les Forêts* (1900), and he followed Boppe at Nancy in the Chair of Silviculture. He called his book *Traité pratique de Sylviculture* (Paris, 1916) which he said was a second, and completely revised, edition of *Les Forêts*; it is, however, an entirely new work. Instead of describing systematically the silvicultural systems and methods of treatment in an abstract manner, as usual in the previous textbooks, he studies the various forest types one after the other—i.e. a chapter on various types of oak forest, another on beech, another on pines, and so on, giving the methods of treatment used in both. Both artificial regeneration and natural regeneration are given in much greater detail than usual because private woodland owners were then having difficulty in regenerating their woods naturally, and a great deal of work in afforesting bare lands was being done by the State. A feature of the book is the chapter on *enrésinement* (the introduction of conifers into coppice-with-standards), a subject on which Jolyet was a well-known authority, and in which the French were then extremely interested. Another useful chapter is that discussing the introduction of artificial understoreys in oak and pine forests. Professor Badoux (of Zürich) spoke very highly of this book, saying that it had come just at the right time when everyone was interested in improving the condition of private woodlands.

Since this book of Jolyet's there has been unfortunately rather a scarcity of silvicultural books from France. Still there is one valuable little book that cannot be omitted. This is Boquet de la Grye's *Guide du Forestier*. First published in 1859, it is now in its fourteenth edition. Its new name is *Technique Forestière*, and the latest edition (1947) has been edited by three of the most distinguished French foresters of the day—MM. Guinier, Oudin, and L. Schaeffer. It is much more than a handbook, for in its 366 pages have been compressed most of the indispensable principles of silviculture and its technique; and more than two-thirds of the book concerns silviculture. To those who come to me and say 'I should like to read a forestry book in French to improve my French' I usually say, 'I'm sure you will find Bouquet de la Grye exactly what you want'. But there are several books of what can be called 'marginal literature' with which every student of French silviculture should be familiar. Such a one is *Les Sols forestiers* (Paris, 1908) by Professor Henry, a trained forester and the first to discover that forest litter contained bacteria fixing nitrogen from the air, and who was perhaps the first to show how forest and agricultural soils differed.

Of dendrological books I will mention only four: A. Mathieu, *Flore forestière* (Baillière, Paris, 4th ed. 1897); R. Hickel, *Dendrologie forestière* (Lechevalier, Paris, 1932); L. Parde, *Les Conifères* (La Maison Rustique, Paris, 1937); L. Parde, *Les Feuillus* (La Maison Rustique, Paris, 1941).

Hickel (1861–1935) and Parde (1865–1943) have been the two great dendrologists in France of recent years. Both were for many years associated with Barres, the famous arboretum in Loiret started by Gouet in 1870, and the plantation near by begun in 1821 by de Vilmorin. It was de Vilmorin who from 1821 to 1862 organized on the Domaine des Barres the first experiments on the different methods of tending certain forest trees such as Scots pine, Corsican pine (var. *calabrica*), and the American oak. Most of Hickel's writings appeared as articles in journals, but Parde was the author of several well-known books. Both advocated the introduction of exotics despite opposition from the forest department, and for what had been done for exotics up to 1929 one should consult Parde's *L'Introduction des essences exotiques dans les forêts de l'Europe occidentale* (Paris, 1929). Parde was also responsible for the complete catalogue of the species growing at Barres, and a delightful little introduction to French forestry called *Arbres et Forêts* (Colin, Paris, 1938).

A fascinating book giving an account of the forest conservancies and the more important forests in each is *Pour comprendre l'arbre et la forêt* by Thiollier (Hachette, Paris, 2nd ed. 1928). Thioller was a Conservator of Forests and I have always found his book the best for the geography of silviculture in France.

A useful book for anyone who cannot read French is Woolsey's *Studies in French Forestry* (Wiley, New York, 1920). Professor Badoux of Zurich said that it was *pour la sylviculture française une réelle revanche*, for up till then the Americans had been more under the influence of German methods (Saxon mainly) than those of France. Woolsey had also pointed out that the art of forestry in France was characterized by a true and objective observation of facts with the use of simple methods.

PERIODICAL LITERATURE.

Periodical literature is, of course, full of silvicultural articles. The two best journals are the *Revue forestière française* (formerly the *Revue des Eaux et Forêts*), published by L'École nationale des Eaux et Forêts, 14 rue Girardet, Nancy; and the quarterly bulletins (Bulletin Trimestriel) of the *Société forestière de Franche-Comté et des Provinces de l'Est*, Salins-les-Bains (Jura).

Private woodland owners form a syndicate which issues from its office, at 46 rue Fontaine, Paris, bulletins (irregularly) called *Bulletin du Comité des Forêts*. These are often very interesting.

Forest research is concentrated at Nancy, where there has been a Research and Experiment Station since 1882. The results of work done there are published in the *Annales de l'École Nationale des Eaux et Forêts* which appear on the average once a year. A very good account of forest research in France appeared in volume ii (1928) of these *Annales*.

I should like to finish this article with a reference to three articles written by

distinguished French foresters in English journals. Professor Broillard wrote two articles on thinnings in the *Transactions of the Royal Scottish Forestry Society*—one in the 1901 and the other in the 1904 volume—and Professor Oudin contributed one on general forestry in France in the 1932 volume of *Forestry*.

ACKNOWLEDGEMENT.

I should like to thank the Librarian of the Imperial Forestry Institute, Oxford, for the loan of several books in the last three years that I might not otherwise have been able to study.

THE LATE PROFESSOR F. T. BROOKS, C.B.E., LL.D., F.R.S.

Frederick Tom Brooks died on the 11th March 1952, at Cambridge, in his seventieth year. We have lost not only one of the most eminent mycologists of our time, but also a man of penetrating and sane judgement, and a most delightful personality. He may, on occasion, have looked solemn and even severe, but his humour always kept bubbling up, and those who knew him will not forget his laugh, unrestrained and infectious.

He was born in Somerset, but his whole working life was spent at Cambridge, from the time he came up to Emmanuel College in 1902, except for one year he spent in Malaya in 1913–14, studying diseases of rubber trees. He was a pupil of the late Professor Marshall Ward who guided him to mycology, and who may also have been responsible for his interest in trees and forestry. He was successively Demonstrator, Lecturer, and Reader in Botany, and he succeeded Sir Albert Seward in the Chair of Botany in 1936; he retired four years ago.

His research in the field of mycology was wide ranging, his first notable work being on the silver-leaf disease of fruit trees. He also stimulated and trained many pupils, many of whom occupy important posts throughout the Empire. His book, *Plant Diseases*, which appeared first in 1928, is one of the most useful in this field. I recall he told me once that he had written it by putting in two hours each day before breakfast.

He was interested in trees and forestry during most of his life, and this was amply demonstrated when we both spent some time in East Africa in 1929. He joined the Society of Foresters of Great Britain in 1936, and although he took no active part in its affairs, he was always interested in its progress. He was a member of the Forestry Commission Advisory Committee on Research for a long period, and, particularly since the war, made an important contribution to advance in knowledge in the field of nutrition of seedlings in nurseries, as Chairman of a Sub-Committee on that subject. His vast knowledge of fungi and their ways was always available, and was of great value, for example, in the recent outbreak of *Fomes annosus* after cleaning and thinning of pinewoods in East Anglia. Dr. Rishbeth, who investigated this subject and published papers on it in this Journal, was one of his pupils.

Thus his work, not only in the field of mycology but also in forestry, will not be forgotten. Those who knew him will cherish the memory of the man 'F. T.' while they live.

H. M. S.

SOCIETY'S AND OTHER NEWS

EXCURSION AND ANNUAL GENERAL MEETING, 1951

As mentioned briefly in the previous number, the Society celebrated its semi-jubilee with a meeting and excursion centred at Oxford, where the Society was founded in 1926. This number opens with a brief record of the event which is followed by Lord Robinson's speech at the dinner and the President's Address at the Annual Meeting. Excursions were made to the Forestry Commission's Research Station at Alice Holt Lodge; to the Kennington nursery, to Bagley Wood, and to the Imperial Forestry Institute at Oxford; to Cirencester Park; to the Hampden Estate; and to the Forest Products Research Laboratory at Princes Risborough.

For an account of the work being undertaken at Alice Holt reference is invited to Mr. Hiley's review of the second separate report on Forest Research for the year ending March 1950 and to the report itself. The review will be found in the previous number of this *Journal*. The new buildings of the Imperial Forestry Institute at Oxford were opened by Princess Margaret in October 1950. Several accounts have been published of the opening and of the timbers used for panelling and for furniture, and notably in *The Empire Forestry Review* for December 1950. The Forest Products Research Laboratory was set up in 1925 and moved to its present site in 1927. Details of the research undertaken will be found in the reports of the Board. A notice of the latest report issued will be found below in this number. The Society was delighted to meet Sir Ralph Pearson, the first Director, at the Laboratory together with his successors, Mr. W. A. Robertson and Dr. Henderson.

In the Bathurst Estate Woods the party was ably shown round by Mr. Garfitt. Rehabilitation after some very heavy fellings during the war started in 1946 under the advice of the late Mr. Ray Bourne and aims at mixed irregular woodland. Advantage is taken of existing advance growth of any useful species, and natural regeneration depended upon for the restocking of a high proportion of the area. At the Kennington nursery Miss Benzian from the Rothamsted Experimental Station demonstrated nutrition experiments and many members were glad to meet again Mr. Gray, who has charge of the nursery and who demonstrated the cultivation of poplar, vegetative propagation, sterilization, chemical weed control, and composting. Thence the party proceeded to Bagley Wood. The main wood has been the property of St. John's College since very shortly after its foundation, in 1555, having been part of a royal estate till the late tenth century, when it was granted to the nearby abbey of Abingdon. The woods were worked under coppice and coppice with standards to meet the college's needs for fuel and timber. Since the opening of the School of Forestry in 1906 the college has given full facilities for the instructional use of the woods. The woods are shortly to be brought under the Dedication scheme. The new working plan written by Dr. Anderson aims at irregular mixed broadleaved high forest. Conifers are to be limited to irregular groups or used as nurse crops over young broadleaved plantations. At the Hampden Estate the party was shown round by the Earl of Buckinghamshire and visited Winchester, Monkton, and Keepershill woods. In Monkton Wood the successful openings made in the canopy by Mr. Hobart-Hampden to save the regeneration resulting from the heavy beech mast of 1922 were seen and some discussion took place on the problem of beech regeneration in the Chilterns.

The Society is extremely grateful to the President of St. John's College and to the Bursar; to Earl Bathurst and to the Earl of Buckinghamshire; to the Director of Research, Forestry Commission; to the Director of Forest Products Research; to the Head of the University Department of Forestry, Oxford; to all others who helped to make the meeting and the excursion a success, and particularly to Mr. G. W. Backhouse and to Mr. Galloway for the very great amount of work well spent on organization and arrangement of the excursion and meeting.

It is perhaps worth mentioning as a footnote that the tree in St. John's College that caused so much interest to members on their way to bathe was appropriately a locust—*Robinia pseudacacia* var. *monophylla*, the more typical leaves of the genus being visible only in the uppermost branches.

HONOURS

Satisfaction will be felt at the announcement in the New Year Honours List of His Majesty's intention of conferring a Baronetcy of the United Kingdom on Major R. G. Proby, M.C., J.P. Major Proby was until recently Chairman of the Central Land Owners' Association and has been a member of this Society since 1946. His services to British forestry are well known.

Among other names in the same list we were glad to see that of Mr. G. J. Cameron, Head Forester, Buccleuch Estates, Bowhill, Selkirk. Mr. Cameron, who has been a member of the Society since 1929, was made M.B.E.

INCOME TAX COVENANT SCHEME

It is understood that 59 members have up to the end of 1951 signed the bond. This will give considerable help to the finances of the Society and it is hoped that others, who are able but have not yet done so, will come into the scheme during the year.

EXCURSION AND ANNUAL GENERAL MEETING, 1952

As announced briefly in the previous number, it is intended to hold the meeting this year in Dumfries. The excursion will be in the Dumfries district and will take place towards the end of September. The forests to be visited will include those on the Buccleuch Estates near Langholm, the Forestry Commission areas of Dalbeattie and Forest of Ae, and the private estates of Shambellie, Kirkennan, and Mr. John Gladstone's estate of Capenoch.

LIST OF MEMBERS

It is intended to print lists of the names of members in the *Journal* annually starting in January 1953. These lists will take the place of those sent out periodically by post. To ensure that the printed lists are accurate and up-to-date, members are asked to examine the last list received and to call the attention of the Secretary to any alterations needed.

REVIEWS

Estate Forestry. By Sir William Ling Taylor, C.B.E. Crosby Lockwood & Son Ltd., 39 Thurloe Street, London, S.W.7. Price 15*s*.

Review by F. K. Makins

ALTHOUGH forestry is an art founded on scientific principles that are universally applicable, the approach to it by the man who is chiefly dependent on his own resources must inevitably be rather different from that of the State forester. New ideas about private forestry are therefore always welcome, especially when presented in readable book form such as this. We have too few up-to-date books on estate forestry. It goes without saying that the views of Sir William Ling Taylor, whose long record of technical and administrative ability raised him to the rank of Director-General of the Forestry Commission, are worthy of very serious attention.

The introductory chapter outlining the conditions governing estate forestry is fair enough. It acknowledges the nation's debt to private forestry and the justice of its claim to help from the taxpayer. No reference is made to the undeniable neglect of private woodlands by the Forestry Commission between the wars and for which Sir William Taylor himself cannot disclaim all responsibility.

There is not space to comment in detail on the author's treatment of the art of forestry in general. It is eminently sound, sensible, and well expressed, and full of practical hints of the utmost value to the man who is doing the job.

The last seven chapters are of particular interest to those who are responsible for the management of private woodlands, whether as owners, agents, or consultants. Some excellent advice is given on measuring and lotting timber for sale and drawing up agreements. The warning that auction can perhaps be regarded as the least suitable means of disposing of standing timber should be heeded. Attention is drawn to the need for a detailed and accurate valuation of timber on estates sold freehold in lots. This is not always done as it should be. Often the value of the timber alone has been found to exceed the whole of the price paid to the original owner.

On the marketing of thinnings the advice given, though valuable, ignores the crucial factor of transport. It is easy to say that 'success will always be in direct ratio to the trouble taken to find out what is wanted, where it is wanted, and how the purchasers want the material for utilization or trade'. Unfortunately, with rising costs it is not possible to market thinnings at a profit from all parts of our island, as the Forestry Commission have themselves found. It is only by a national policy co-ordinating the efforts of the Forestry Commission, private growers, and merchants, and not by piecemeal attempts by growers, that the thinning problem can be solved. The Forestry Commission should have taken the lead in formulating such a policy instead of standing aside and admonishing the small grower for lack of enterprise.

The case for forestry on the farm has never been put more convincingly. We agree with every word, but it needs a special whole-time department to get anything done. The average farmer has little knowledge of or interest in trees. He can recognize oak, ash, elm, and beech. He is likely to confuse all the others and cannot usually tell one conifer from another. Trees to him are convenient posts to which to nail wire or to cut down when he wants cash. Most farm spinneys, too, are in a deplorable state and cannot be improved

without the expenditure of much time and money, neither of which the farmer will give. No wonder the woodlots are bulldozed and turned into leys.

The book deals at some length with co-operative forestry. To quote: 'Its most able and earnest advocates have faith but probably few illusions concerning its pitfalls'; and again, 'it is now agreed on all sides that State aid to forestry co-operators is a pre-requisite to success at least until the movement can stand firmly on its feet'.

The question is asked whether private forestry can be made to pay and is answered in the affirmative. We agree that it can be made to pay as soon as the derelict stage is passed, sport and amenity subordinated to timber production, and proper accounts kept. But do owners really want it to pay, and if so, what are the prospects of efficient management? If not, what are the alternatives? The dedication scheme has been accepted by comparatively few estates and is concerned rather with planting and thinning than with the economic aspect. Unless the response is much greater and more rapid the State will have to take over the management of a large number of woodlands. Perhaps the discussion of such a possibility is outside the scope of the book, but it will soon become a live issue in estate forestry. No one wants to see it brought about, least of all the State. Probably the best way to avoid wholesale acquisition is to share the faith of the co-operative associations, give them the greatest possible assistance, and allow them reasonable time in which to become effective. It is likely to be cheaper in the end.

Sir William is anxious that the private forester shall not be frightened by the bogy of compound interest. It is true, as he says, 'that no ordinary investor can protect capital, and assure income with certainty throughout the duration of a long-term productive enterprise that is subject to any sort of natural hazard however slight'. The fact remains that in our capitalist economy a sum of money can be made to accumulate at compound interest. If forestry cannot yield a like return it is relatively unprofitable.

The book is especially valuable in that it is written by an experienced State forester with knowledge and appreciation of the difficulties of estate forestry in the past as well as the present, and is an important addition to the literature of forestry in Britain. It is well illustrated with good photographs by the Forestry Commission, R. C. B. Gardner, and others.

Forest Engineering: Roads and Bridges. By James L. Harrison. Oliver & Boyd Ltd., Tweeddale Court, Edinburgh 1. 1951. 30*s.* net.

Review by A. H. Lloyd

THE term 'Forest Engineering' usually implies the many varied field engineering works and associated technical problems met with in general forestry practice. A text-book covering all the subjects involved would be either too superficial to have any value or too lengthy for a single volume, and Mr. Harrison has wisely limited the present book to roads and bridges. A simple practical treatise of this kind is badly needed. Civil Engineering text-books on these two important subjects are too abstruse for forestry needs and the excellent pre-war Field Manuals of the Royal Engineers, which have long been used in Forestry Schools, are now out of print and have been replaced in the Army by books on 'Bailey' steel-girder bridging and on the uses of heavy mechanized equipment for road construction.

Mr. Harrison's book deals first with the location and alignment of forest roads and the estimation of costs, including simple methods of measurement of earthwork. He writes

from his own long practical experience in India, but although some of the illustrations and examples are drawn from tropical sources, the major part of the book will be found directly applicable to conditions in Great Britain. The great importance of the early selection of the best alignments for extraction roads is rightly stressed, in order to avoid the later adjustments and costly clearings which have recently been found necessary when extracting thinnings from some of the hillside conifer plantations both here and in East Africa. The clear demarcation of such alignments by stout and durable pegs before planting is begun has obvious advantages but apparently is still often overlooked. The uses and merits of an Abney Level for the measurement of gradient will be well known to forest officers, but the 'Ghat Tracer' and the Indian Tangent Planimeter, also advocated in the chapter on alignment, are now probably unobtainable in Great Britain.

Methods of road drainage and the construction of simple culverts and causeways with local materials are well described and illustrated, as is the regular use of simple wooden road 'drags' to prevent the formation of ruts in earth roads which is a common practice in America and might well be adopted on muddy extraction roads here.

The use of 'trackways' or traffic strips, formed of gravel, road-metal, or concrete filled in two shallow trenches about 2½ feet wide, is advocated in the chapter on road construction. For extraction roads with limited traffic this may be economical, especially in localities where stone is expensive, but in Southern Rhodesia, where concrete strips have now been used for many years, the present tendency is to abolish them, as unless the concrete is very carefully laid on good solid foundations, the tracks have been found dangerous to modern fast traffic and also costly to maintain.

A chapter on the use of various explosives in the quarrying of road-metal gives detailed directions which could be followed with confidence by a forester with no previous experience of quarrying. Readers are rightly warned to acquaint themselves with local government orders before purchasing or using explosives, but some government regulations tend to over-stress the risks, which are actually very small if normal precautions are taken.

As an introduction to timber bridge construction there are two chapters on Timber Testing and Timber Mechanics. These describe the methods employed at Forest Products Research Laboratories and will probably be found more useful to the student than to the forest officer in the field. This also applies to the methods of calculation for the 'Maximum Bending Moment for two Rolling Loads' given in detail in Chapter XII, as with the many variable factors in timber bridge construction it should be sufficiently accurate to assume the total load of a moving vehicle to be on one axle only. Constructional details and well-dimensioned drawings are given of simple timber bridges, including strutted and trussed beams, and the use of crib and trestle piers. The descriptions give just what is needed by a forest officer building his first timber bridge and are obviously drawn directly from the long personal experience of the author.

Pile-driving and the construction and use of drop-hammer pile-drivers is well described with numerous illustrations. The photograph given of the badly decayed top of a round timber pile resulting from the common method of notching two capsills into the sides of the pile is a convincing proof of the disadvantages of this method compared with the use of one heavy sill covering the whole top of the pile. The prevention of early decay of bridge decking by ensuring that rain-water is quickly drained off, and by using timber preservatives, is particularly applicable to the softwood decking now frequently used in small forest bridges, but the methods described to create a waterproof coat to the decking with asphalt or tar and a top covering of bitumen would appear to be less practicable for ordinary decking, which is flexible and moves considerably under traffic.

Counter erosion works, particularly for the protection of bridge abutments, is well dealt

with in a chapter on river training. The revetment of banks and the use of stone and timber spurs is described, but modern continental methods using wire-netting to contain stone 'bunds' and spurs are omitted.

In a final chapter on timber carpentry joints the uses of metal timber connectors are described, including the 'bulldog' plate connector which is now becoming better known in this country, particularly in prefabricated roof trusses. In America and Canada these connectors have been used for many years in softwood bridge-building.

Mr. Harrison is to be congratulated on producing a sound and useful book on a difficult subject. It is full of practical hints and advice on the actual methods and details of construction of roads and bridges which will be much appreciated by forest officers faced with these problems.

Distribution of Tree Species in the Sudan in Relation to Rainfall and Soil Texture. By J. Smith. Sudan Government Ministry of Agriculture Bulletin, No. 4. 1949. Khartoum. 68 pages and 17 maps, diagrams and graphs. Price P.T.40.

Review by A. C. Hoyle

THE Anglo-Egyptian Sudan is vast in extent and lacks certain factors which elsewhere encourage confusion in ecological interpretation. Humidity and length of rainy season increase together from north to south through a rainfall range of 0–1,400 mm.; major physiographic features are few; geology is not complex and soils are in general mature. With the length and severity of the dry season profoundly influencing vegetation, the role of water becomes of paramount importance. This role, combined with that of variation in the physical properties of the soil, is the main subject of Dr. Smith's convincing arguments.

Parts I and II briefly describe the geography, climate, and soils and classify and discuss the vegetation types. The classification is mainly physiognomic and emphasizes the height and density of grass in relation to the fire factor; this controversial basis for terminology tends to be adopted by experienced African ecologists, especially foresters, because of its usefulness, but those who are trying to define the difference between forest and savannah woodland on a similar basis may hesitate to accept 'Mixed Deciduous Fire-Swept Forest' as a synonym of the 'older' term 'broad-leaved savannah forest' (p. 9). Moreover, recent discoveries discount some of the floristic differences given between the southern 'Lowland Forests'. Some of the differences suggested between gallery forest types are misleading and, except for *Lophira*, the examples of 'species polymorphism' are pairs of fundamentally distinct species.

The main evidence in Chapters II–IV of Part II is cleverly analysed with striking coloured diagrams of different kinds of transect. Species-dominance changes with contour and soil within a limited area of constant rainfall; a single species occurs on different sites with changing rainfall; species progress through their rainfall span via the same sequence of sites; species appear in a definite order on the same type of site through gradually changing rainfall. The reviewer's limited personal experience of the Sudan does not permit detailed criticism of records which are, however, in general agreement with his own. These latter are relatively few in the northern part of the country which provides the main source of Dr. Smith's evidence.

The principal conclusions drawn in Part III from the transects and other considerable evidence are that the higher the clay content of the soil, the higher is the rainfall required

by a given species, and vice versa. The 'climatic climax' or 'datum' soil has such a topographic position and texture that it receives only direct precipitation and loses it only by evaporation. The 'datum' clay content proper to the climate bears the species dominant proper to the climate.

The practical outcome of all this is the unconventional but sound concept that, for the perennial plants studied, the 'wettest' soil in a dry region is a well-drained sand and the 'driest' soil is a badly drained clay because its dry-season chresard, or water available to plants, is lower by reason of texture. Records and experiments are cited to show that afforestation is unsuccessful on the northern clay plains, but successful on islands of sand trapped upon them by surviving native species. *Prosopis juliflora*, in particular, is estimated to be an economic fuel crop after 15 years' experience. Plants are pot-grown until old enough to withstand attrition by sand.

It is a pity that so valuable a publication should frequently distract the reader by small, irritating errors. There are gaps, for instance, in the numerical sequence of plates and bibliography, errors in text-references, and faulty alphabetical order in the list of species; Plates III and IV do not fully tally with their legends; on Plate VII *Acacia hebecladoides* has been missed by the proof-reader; another species on this plate, *A. stenocarpa*, does not appear in the 'index' (Appendix I) but is replaced by *A. seyal* var. *multijuga*, the name cited for it in the only paper in the *Journal of Ecology* (1948) which, to our knowledge, deals specifically with Sudan ecology, and this paper is not cited. Most of such errors, and the somewhat epigrammatic style, probably arose in 'boiling down' from Dr. Smith's longer thesis.

The lessons to be learnt from his stimulating book are not applicable only to the tropics. Introducers of exotics should consider site and soil as well as the climate of the country of origin, particularly from the standpoint of the texture-rainfall factor. A species may be very versatile in response to clay-content or rainfall, but its rainfall-requirement for a given clay-content, and the range of texture it will tolerate under a given rainfall, may both be very limited. Many expensive mistakes would have been avoided if such warnings had been available, and heeded, in the past.

Australian Rain-Forest Trees, including notes on some of the tropical rain forests and descriptions of many tropical species. By W. D. Francis, Government Botanist, Queensland. Pp. 469, with 260 full-page half-tone illustrations, 24 text-figures, and a rainfall map. (First published 1929.) New and Revised Edition, 1951. Forestry and Timber Bureau, Commonwealth of Australia, Canberra. Price not stated.

Review by C. W. Scott

THE first edition of this excellent book was reviewed by W. Dallimore in *Forestry*, iv. 1, 1930, pp. 57–58. The praise then given, that '. . . it might well be taken as a standard for descriptive works on forest trees in other parts of the Empire', was well deserved and may be endorsed for the revised edition, with its extended range. The excellence of the botanical descriptions and illustrations of the trees is matched by the short practical notes on the uses of their timbers. These uses depend in many cases on chemical treatment against borers, and obviously imply prompt sawing and drying, if perishable woods in the tropics or sub-tropics are to be satisfactory, as they can be when so handled. A very good

feature of all the illustrations, whether of leaves, flowers and fruits, or of boles or whole trees, is that the scale is given, by one means or another, so that the forester or the lumberman may size up the species from the point of view of utilization. Those who know some of the trees or their near relatives in countries other than Australia may note the uses recorded for Australia of species of well-known genera such as *Gmelina*, *Nothofagus*, *Alstonia*, and *Ficus*. The background visible in many of the photographs will evoke nostalgic memories in those who have worked in tropical or sub-tropical rain forests, and may well suggest a measure of humility or thankfulness for those whose field is the less complex one of European forests, especially conifers.

A Preliminary Enquiry into the Influence of Solar Radiation on Insect Environment, with Special Reference to the Relation between Pest Epidemics and Fluctuation in Solar Radiation. By W. B. R. Laidlaw. Transactions of the Society for British Entomology, Vol. II, Part 2, pp. 17–80. 31st October 1951. Price 7*s.* 6*d.* post free from the Secretary, 454 Christchurch Road, Bournemouth, Hants.

It has been unfortunately necessary to withhold the review on this important paper until the next number owing to lack of space. A review by R. Neil Chrystal will appear then.

NOTICES

Report of the Forest Products Research Board with the Report of the Director of Forest Products Research for the year 1949. Department of Scientific and Industrial Research. London: His Majesty's Stationery Office. 1951. 8 Plates and 1 Figure. 50 pages. Price 2*s.* 6*d.* net.

THE Board records the increasing time spent by the staff on advisory work and on short-time investigations for industry and for Government at the expense of work of a more fundamentally scientific character, but adds, 'it has been possible to make a small, though we believe inadequate, increase in such work'. The Director in the introduction to his report remarks that while practical inquiries are the life-blood of a technological establishment and while the increasing flow of industrial inquiries is a healthy sign of the increasing confidence of the trade, the increase places the laboratory in a progressively difficult dilemma. The problem is one of staffing, and no solution has yet been found. The project on the testing of colonial timbers still enjoys highest priority. The report records the work undertaken by the principal research sections, Wood Structure, Physics, Seasoning, Timber Mechanics, Wood Preservation, Chemistry, Mycology, Entomology, Wood Working, and Composite Wood through which members were so ably conducted in September last when the Society visited Princes Risborough. A few gleanings are below.

Experiments have been started to elucidate the changes accompanying the transformation of sapwood to heartwood which involve disappearance of plant reserves used as food by *Lyctus* and may also involve differences in natural durability. Tests on twenty-five exotics have failed to find any with bending properties equal to beech. Interest continues to be shown in the 'continuous strip' method of making laminated bends. Tests made on timber structures included a Dutch barn of shear connector portal frame construction and a glasshouse based on asymmetrical laminated timber arches designed by the Timber Development Association. A scheme of yield measurement has been evolved to assess quantitatively the suitability of a species for plywood manufacture. A special technique has been developed for recording by high-speed photography the distribution and movement of sawdust in and around the gullets of saws while the latter are cutting. An investigation involving a visit to Northern Rhodesia and yielding valuable information on the sawing of refractory timbers was carried out on the sawing of dry and fire-killed logs of 'Rhodesian teak' (*Baikiaea plurijuga*), of which it was estimated that several million cubic feet of timber might be utilized if a suitable technique of sawing could be found. The use of hard-tipped inserted saw teeth was necessary and Stellite, an alloy of cobalt, chromium, and tungsten, was chosen for tipping and satisfactory methods of depositing the Stellite evolved. In wood preservation the main technical barrier to further progress is impermeability, and work in this field is mainly confined to Douglas fir, one of the most difficult structural softwoods to treat satisfactorily with preservatives. Investigation into a case of dermatitis attributable to dust from *Paratecoma peroba* (Bignoniaceae) led to some interesting confirmation of early observations on lapachonone. The value of some of the newer insecticides against infestation by pin-hole borers into recently felled logs has been under investigation in the Gold Coast, Malaya, and British Honduras. Here Gammexane water-dispersible dust P. 250 has so far given the best results. Heat sterilization in a kiln is still the only reliable means of destroying on a commercial scale all stages of *Lyctus* in a single treatment. The inclusion

of 1 per cent. Gammexane in an animal glue has been shown to prevent attack by *Lyctus brunneus* in plywood up to 17 months.

The report is well illustrated and interestingly written. It is a pity that it should take such an inordinate time to reach the public.

Hedges, Shelterbelts and Screens. By A. D. C. Le Sueur. Country Life Ltd., 2–10 Tavistock Street, London, W.C. 2. 124 pp. 28 plates. 15*s.* net. 1951.

MR. LE SUEUR has drawn on his vast practical experience and written a book which is packed with sound advice. The demand for ornamental hedges is probably as great as ever and advice is given both on what to plant and what not to plant. Equally sound is the advice given about the right time of the year to plant, e.g. cypresses in October or April and not in mid-winter, and about the time to prune in the case of flowering hedges. More might have been said about shrubs and trees tolerant of smoke and town conditions. Changes in agricultural practices have called a halt to the making of hedges and in many places to the upkeep of existing ones. The next 50 years will inevitably show big changes in the face of the countryside, and Mr. Le Sueur's plea for the hedgerows and for hedgerow trees of the right kind will be welcome. There are two excellent chapters on farm shelterbelts. The danger of poplar roots spreading and damaging buildings and drains is shown in two excellent photographs and is most timely. Mr. Le Sueur admits difficulty about quoting prices, partly because the nursery trade has barely recovered from the war and partly because of ever rising costs of labour. He considers that, generally speaking, costs have risen sixfold in the last 40 years, corresponding to a similar rise in agricultural wage rates. There will be agreement with his figures for the cost of trimming and of laying hedges, though this is work generally done when other work on the farm is at a standstill. If the cost of yew given at the top of page 20 persists, it should deter the planting of this often dangerous tree.

The Commoners of Dean Forest. By Cyril E. Hart. The British Publishing Company Limited, Gloucester. 1951. 179 pp. 14 plates and 2 maps. 15*s.* net.

THE earliest record of right of common in the Forest of Dean is a charter of 1154 which Henry II granted to the monks of Flaxley. In 1216 King John instructed the Constable of St. Briavels Castle to restrict the grazing of cattle to the fringes of the forest and away from places frequented by the wild boar. Thence Mr. Hart sets down the information available through the legislation of 1668 enclosing 11,660 acres for timber production for the Navy to the present day. To call attention to the purpose of this scholarly and fair-minded book, some extracts are given below from the foreword by Mr. D. W. Young, who notes that there are estimated to be over 2 million acres of common land in England and Wales and that commonage is a wasteful way of using the land.

'Surely by grouping the country's commons and putting them under the administration of Courts of Verderers we have a way of using our commons far more effectively. But it would be worse than useless to assume that the common rights are identical in all these commons. Common rights are one of the outcomes of history and that history varies from common to common. The first essential would be for the Verderers or someone acting for them to delve into all such records as are available and extract as complete a history from them as possible. This Mr. Hart has done for the Forest of Dean on his own initiative, and he has made a first class job of it. We owe him our congratulations and thanks for what must have been long and sometimes wearisome research amongst a voluminous but often very incomplete mass of historical data.'

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